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Fixed Ground Antenna Radome (FGAR) Type II Operational Test and Evaluation (OT&E) Operational Test (Lihue Terminal Radar Facility) Final Report

Leonard Baker

February 1997

DOT/FAA/CT-TN97/1

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16. Abstract

This report documents the Operational Test and Evaluation (OT&E) Operational testing performed on the Type II, Fixed Ground Antenna Radome (FGAR) First Article installed at a terminal radar facility. The Type II FGAR is used at: (1) Mode Select Beacon System (Mode S) and Air Traffic Control Beacon Interrogator (ATCBI) beacon only sites (BOS), and (2) selected terminal radar facilities which experience severe environmental conditions.

This testing was performed on the Federal Aviation Administration's (FAA) Western-Pacific Region's Lihue Terminal Radar Facility (LIH), Hawaii (HI). The testing was limited to electromagnetic performance characteristics evaluation and human engineering tests.

Electromagnetic performance characteristics data were collected by the Honolulu Combined Center/Radar Approach Control (CERAP) [ZHN]. The testing showed the FGAR did not degrade the antenna electromagnetic patterns.

The human engineering test showed that the FGAR Zenith Service Hatch Assembly mounted equipment can be maintained by FAA environmental technicians.

The testing determined that the FGAR meets the Operational Suitability and Operational Effectiveness requirements of the FAA.

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EXECUTIVE SUMMARY

Operational Test and Evaluation (OT&E) Operational testing of the Type II Fixed Ground Antenna Radome (FGAR) First Article installed on a Airport Surveillance Radar (ASR)/Air Traffic Control Radar Beacon System (ATCRBS), was performed at the Lihue, Hawaii (HI) Terminal Radar Facility (LIH). The testing was limited to electromagnetic performance characteristics evaluation and human engineering.

Electromagnetic performance characteristics testing was accomplished by collecting data at the Honolulu Combined Center/Radar Approach Control (CERAP) [ZHN]. The Honolulu CERAP Service Support Center (SSC) [ZHN] Radar Data Acquisition Subsystem (RDAS) Engineer analyzed the data using their En Route Automated Radar Tracking System (EARTS) Quick Analysis of Radar Sites (EQARS) and Transportable Radar Analysis Computer System (TRACS) programs, which were run on their EARTS system and a International Business Machines (IBM) Corporation compatible personal computer (PC). In addition, a flight check was performed to commission the Lihue Terminal Radar Facility (LIH) primary (ASR) and secondary (ATCRBS) radars.

Before and after installation of the FGAR, electromagnetic performance data could not be compared because: (1) the Common Digitizer (CD)-1 at the Lihue Terminal Radar Facility (LIH) had not been optimized when data were collected before the FGAR was installed. The CD-1 had been optimized when data were collected after the FGAR was installed. This invalidated any data comparisons, and (2) data were not remote to the Honolulu CERAP (ZHN) until after the FGAR was installed. The testing showed the electromagnetic performance characteristics of the primary (ASR) and secondary (ATCRBS) radars were usable for Air Traffic Control (ATC).

Human engineering was limited to verifying that environmental technicians can service the Aircraft Obstruction Lights (AOL) and other Zenith Service Hatch Assembly mounted equipment.

In conclusion, OT&E Operational testing determined that the Type II FGAR used with an ASR/ATCRBS installation, meets the Operational Suitability and Effectiveness requirements of the Federal Aviation Administration (FAA). The Type II FGAR installed at the Lihue Terminal Radar Facility (LIH) is ready to be integrated into the National Airspace System (NAS).

1. INTRODUCTION.

1.1 PURPOSE.

The purpose of this report is to provide the results of the Operational Test and Evaluation (OT&E) Operational testing performed on the Type II Fixed Ground Antenna Radome (FGAR) First Article installed at the Lihue, Hawaii (HI) Terminal Radar Facility (LIH).

1.2 SCOPE.

OT&E Operational testing of the Type II FGAR was divided into two phases. The first report covered the Type II FGAR installed at the Rockville, Nebraska (NE) Beacon Only Site (BOS) [QJM], which had a Mode Select Beacon System (Mode S) antenna installed. This report covers OT&E Operational testing of the Type II FGAR installed at the Lihue Terminal Radar Facility (LIH), with an Airport Surveillance Radar (ASR) and a Air Traffic Control Radar Beacon System (ATCRBS).

OT&E Operational testing at the Lihue Terminal Radar Facility (LIH) was limited to electromagnetic performance characteristics evaluation and human engineering. Electromagnetic testing could only be performed with the FGAR installed, because: (1) the Lihue Terminal Radar Facility (LIH) was not interfaced with the Honolulu Combined Center/Radar Approach Control (CERAP) [ZHN] until after the FGAR was installed, (2) the Common Digitizer (CD)-1 at the Lihue Terminal Radar Facility (LIH) had not been optimized when data were collected before the FGAR was installed. The CD-1 had been optimized when data were collected after the FGAR was installed. This prevented a valid comparison of the data.

a. The Honolulu (CERAP) [ZHN] collected Lihue Terminal Radar Facility (LIH) data using their En Route Automated Radar Tracking System (EARTS). The Honolulu CERAP (ZHN) Service Support Center (SSC) Radar Data Acquisition Subsystem (RDAS) Engineer then analyzed the data, using the EARTS and available software analysis programs.

b. Kauai Airway Facilities (AF) SSC personnel evaluated the web ladder used to obtain access to the FGAR Zenith Service Hatch.

The Western-Pacific Region had a flight check performed to commission the facility. (The Lihue Terminal Radar Facility [LIH] is a new site which has never been commissioned.) The flight check was not part of OT&E Operational testing, but the results are included in this report.

2. REFERENCE DOCUMENTS.

2.1 FEDERAL AVIATION ADMINISTRATION (FAA) ORDERS.

Order 6190.10	Maintenance of NAS En Route Automated Radar Tracking System
Order OA P 8200.1	United States Standard Flight Inspection Manual

2.2 FAA SPECIFICATIONS.

FAA-E-2773b	Fixed Ground Antenna Radome (Mode S Compatible)

2.3 OTHER FAA DOCUMENTS.

NAS-MD-686	Off-Line Programs
NAS-MD-690	Real-Time Quality Control
NAS-MD-691	On-Line Certification and Diagnostics
SPB-TRA-009	New Radar Analysis Software for the Transportable Radar Analysis Computer System
DOT/FAA/CT-TN93/17	Test and Evaluation Master Plan (TEMP) for Fixed Ground Antenna Radome (FGAR)
DOT/FAA/CT-TN95/23	Fixed Ground Antenna Radome (FGAR) Type I/III OT&E Integration and OT&E Operational Final Test Report
DOT/FAA/CT-TN95/53	Operational Test and Evaluation (OT&E) Operational Test Plan for Type II Fixed Ground Antenna Radome (FGAR)
DOT/FAA/CT-TN95/54	Operational Test and Evaluation (OT&E) Operational Test Procedures for Type II Fixed Ground Antenna Radome (FGAR)

2.4 FAA FIELD TEST REPORTS.

Manager, AOS-230, "Review of Radome EM Performance for ASR-8 (S-Band) and (BI-4) L-Band," September 29, 1995

Manager, Hawaii-Pacific SMO, "Lihue, HI (LIH) ASR-8 Fixed Ground Antenna Radar Evaluation," December 27, 1996

Masingdale, James W., Western-Pacific Region "ASR-8 Flight Check Report, Lihue, HI," undated

3. SYSTEM DESCRIPTION.

3.1 MISSION REVIEW.

The FAA program to implement the En Route Mode S resulted in a requirement to replace the existing radomes at en route radar and BOS facilities. The existing radomes were not physically large enough to accommodate the En Route Mode S back-to-back phased array antennas. Because of its size and ability to provide optimal protection of the enclosed antennas from the outside environment, while providing minimal degradation of the electromagnetic performance characteristics, Type II FGARs are being installed at several ASR/ATCRBS sites which experience extreme environmental conditions. The Lihue Terminal Radar Facility (LIH) is the first of these sites.

Since the FGAR was designed to operate at L-band frequencies, the Electronic Space Systems Corporation (ESSCO) conducted additional Developmental Test and Evaluation (DT&E) testing at S-band frequencies. This testing showed that the Type II FGAR should not have a determental effect on the electromagnetic performance of the primary (ASR) radar. In addition, AOS-230, Surveillance Systems Engineering, was requested to review the test results (appendix A).

3.2 TEST SYSTEM CONFIGURATION.

The Type II FGAR provides an optimal environmental enclosure for the Mode S back-to-back phased array antennas, ATCRBS 5-foot planar array antenna, or an ASR antenna and associated ATCRBS 5-foot planar array antenna. The radome is capable of withstanding wind velocities of 150 miles per hour (MPH). They have an inside diameter of 35 feet at their widest point, and fit the standard beacon only antenna tower (ASR-8 tower).

The radome is supplied as a complete assembly, which includes:

a. Radome base ring.

b. Lightning Protection Subsystem (LPS).

c. Zenith Service and Catwalk Access Hatches.

d. Aircraft Obstruction Light(s) [AOL].

e. Devices to monitor the state of the AOLs and the access hatches condition (open/closed).

3.3 INTERFACES.

The Type II FGAR interfaces both mechanically and electrically with the National Airspace System (NAS). A block diagram of the interfaces is shown in figure 3.3-1.

3.3.1 Mechanical.

The Type II FGAR base ring interfaces mechanically with the existing antenna tower platform.

3.3.2 Electrical.

The Type II FGAR interfaces electrically with the antenna tower/facility:

a. Electrical system.

b. LPS.

c. Remote Maintenance Monitoring System (RMMS)/Environmental Remote Monitoring Subsystem (ERMS).

3.3.3 Interface Testing.

There was no OT&E Integration testing performed on the Type II FGAR. The FGAR electrical interfaces were thoroughly tested during Type I/III FGAR OT&E Integration and Operational testing. The Type II FGAR interfaces were, however, tested during on-site acceptance testing as following:

a. Mechanical.

The mechanical interface between the Type II FGAR base ring and the antenna tower was verified.

b. Electrical.

1. The interface between the FGAR and the facility electrical system was verified.

2. The interface between the FGAR and the antenna tower LPS was tested.

3. The interface between the FGAR and the RMMS/ERMS could not be tested, since the ERMS has not been developed. The FGAR side of the interface, however, was tested.

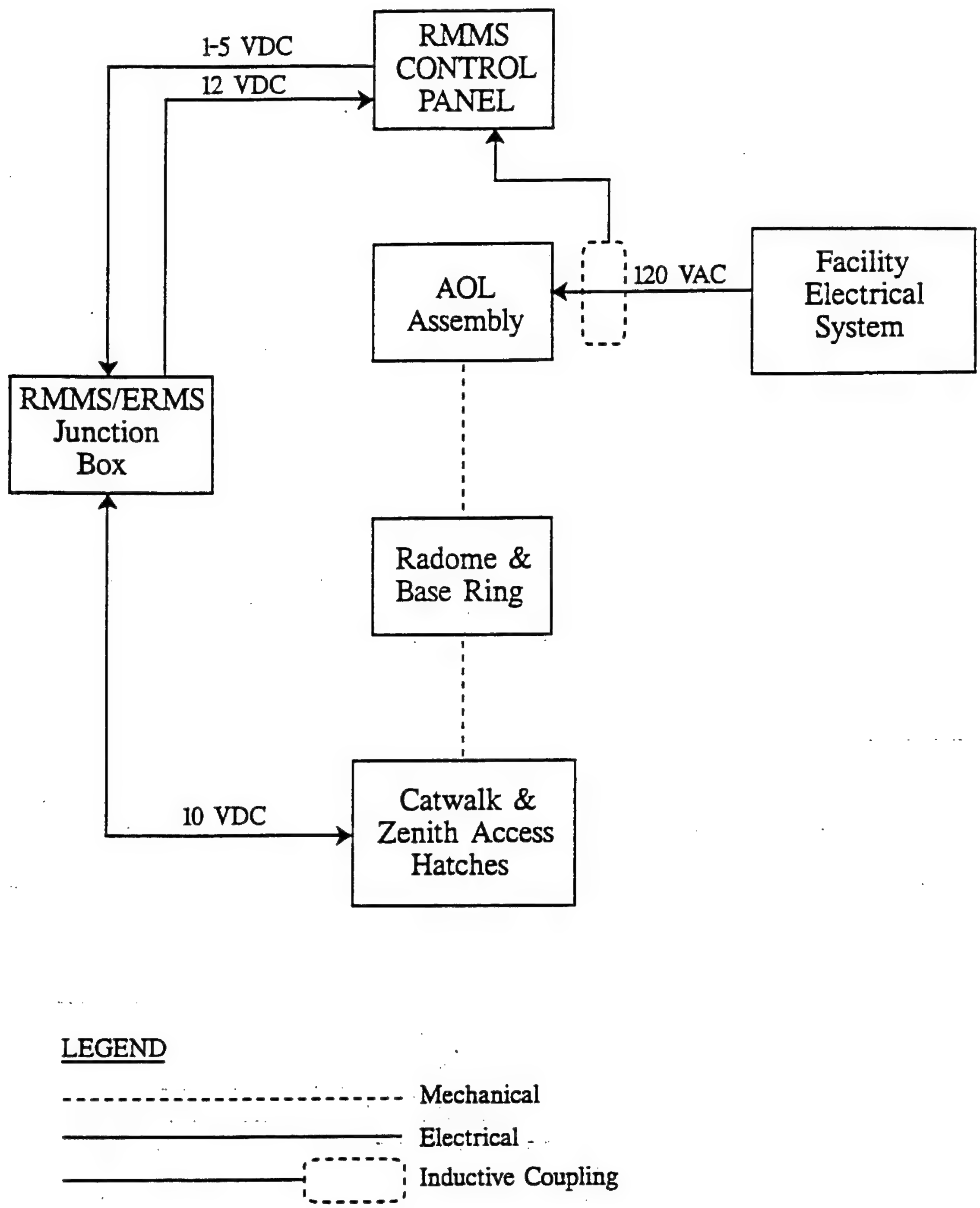


FIGURE 3.3-1 TYPE II FGAR INTERFACES BLOCK DIAGRAM

4. TEST AND EVALUATION DESCRIPTION.

4.1 TEST SCHEDULE AND LOCATIONS.

a. Test Schedule.

1. Electromagnetic testing was performed during the period September 11 to November 27, 1996.

2. Human engineering testing was performed on May 9, 1996.

b. Test Locations.

1. Honolulu CERAP (ZHN)
2. Lihue Federal Contract Tower (FCT) [LIH]
3. Lihue Terminal Radar Facility (LIH) [See appendix B]

4.2 PARTICIPANTS.

The test participants included personnel from several different organizations. Appendix C contains a list of the test participants. The organizations which participated in the testing were:

a. Honolulu CERAP (ZHN) SSC RDAS Engineer
b. Lihue FCT (LIH) Air Traffic Control Specialist (ATCS)
c. Kauai AF SSC Supervisor and Environmental Technicians
d. Lihue Terminal Radar Facility (LIH) Electronic Technicians
e. Vitro/ACT-310B Engineer

4.3 TEST AND SPECIALIZED EQUIPMENT.

The following Government furnished equipment (GFE) and software were used to perform the tests:

a. Honolulu CERAP (ZHN) EARTS and the EARTS Quick Analysis of Radar Sites (EQARS) and Transportable Radar Analysis Computer System (TRACS) programs.

b. Lihue FCT (LIH) Digital Bright Radar Indicator Tower Equipment (DBRITE) displays.

c. Lihue Terminal Radar Facility (LIH) ASR-8 and Air Traffic Control Beacon Interrogator (ATCBI)-4 systems.

The Honolulu CERAP (ZHN) and Lihue FCT (LIH) were commissioned and certified operational facilities. The Lihue Terminal Radar Facility (LIH) was a new installation and had not been commissioned at the time of testing.

5. TEST AND EVALUATION DESCRIPTION.

The Honolulu CERAP (ZHN) collects data from all of the radar facilities with which it interfaces and uses its EARTS to: (1) analyze the data, using the EQARS program, and (2) record the data for analysis by the TRACS program. The EQARS and TRACS programs output data are used to determine if the radar facilities data are usable for Air Traffic Control (ATC). (See appendix D for a description of the programs.)

The Lihue Terminal Radar Facility (LIH) supplies primary (ASR) and secondary (ATCRBS) radar data to the Honolulu CERAP (ZHN), which supported OT&E Operational testing by analyzing the EQARS and TRACS data after the FGAR was installed.

5.1 EQARS AND TRACS DATA REDUCTION (TDR) PROGRAM TESTS.

5.1.1 Test Objectives.

The objective was to determine if the FGAR affected the electromagnetic performance characteristics of the primary (ASR-8) and secondary (ATCBI-4) radars data being received by the Honolulu CERAP (ZHN).

NOTE

> Before and after installation of the FGAR electromagnetic performance testing was not possible, because: (1) the CD-1 at the Lihue Terminal Radar Facility (LIH) had not been optimized when the before installation TRACS data were recorded and the after data were recorded after the CD-1s were optimized, and (2) data were not remoted to the Honolulu CERAP (ZHN) until after the FGAR had been installed.

5.1.2 Test Criteria.

The electromagnetic performance characteristics of the primary (ASR-8) and secondary (ATCBI-4) radars data, as measured by the EQARS and TRACS TDR programs, were usable for ATC.

5.1.3 Test Description.

The Honolulu CERAP (ZHN) ran the EQARS and TRACS TDR programs, using primary (ASR-8) and secondary (ATCBI-4) radar data collected from the Lihue Terminal Radar Facility (LIH).

The critical issue is: Is the primary (ASR-8) and secondary (ATCBI-4) radar data usable for ATC?

5.1.4 Data Collection and Analysis Method.

The Honolulu CERAP (ZHN) collected Lihue Terminal Radar Facility (LIH) primary (ASR-8) and secondary (ATCBI-4) radars data. The Honolulu CERAP (ZHN) SSC RDAS Engineer then analyzed the EQARS and TRACS TDR programs output data to determine if the data were usable for ATC.

NOTE

> The EQARS Radar Site Summary Option (SUM) was used for testing, because the EQARS Radar Site Summary and Track Correlation Option (STK) caused the EARTS system to scatter, i.e., the system fail and the Operational Program to be reloaded.

5.1.5 Results and Discussion.

5.1.5.1 EQARS and TRACS TDR Data Evaluation.

A portion of the electromagnetic performance characteristic parameters measured by the EQARS and TRACS TDR programs are shown in appendix E. It should be noted, however, that Order 6190.10 does not contain pass/fail criteria for the majority of EQARS and TRACS TDR data parameters. The critical TRACS TDR data parameters are shown in tables 5.1.5.1-1 through 5.1.5.1-5.

NOTE

The Blip/Scan Ratio (BLIP/SCAN) is equivalent to the Probability of Detection (PD).

TABLE 5.1.5.1-1 TRACS TDR BEACON BLIP/SCAN RATIO

Fail Criteria	LIH %
<90%	99.12

TABLE 5.1.5.1-2 TRACS TDR MODE 3/A RELIABILITY

Fail Criteria	LIH %
<98%	99.68

TABLE 5.1.5.1-3 TRACS TDR MODE 3/A VALIDITY

Fail Criteria	LIH %
<95%	99.47

TABLE 5.1.5.1-4 TRACS TDR MODE C RELIABILITY

Fail Criteria	LIH %
<98%	99.61

TABLE 5.1.5.1-5 TRACS TDR MODE C VALIDITY

Fail Criteria	LIH %
<92%	99.09

5.1.5.2 Honolulu CERAP (ZHN) Evaluation.

The Honolulu CERAP SSC RDAS Engineer analyzed the EQARS, TRACS TDR, and commissioning flight check data with the following results (see appendix F):

a. Air Traffic (AT) were satisfied with the results of the flight inspection, up to an altitude of 20,000 feet, the design limit of the ASR-8 radar.

b. All of the EQARS and TRACS TDR radar summaries were within tolerance with the exception of:

1. The EQARS radar reinforced percentage (RR %) was 64.62 percent (failure criteria is less than 80 percent). This was caused by the low number of aircraft per scan causing the beacon permanent echo (BPE) [parrot] to skew the reinforcement rate.

2. The TRACS TDR search blip-scan ratio was 72.65 percent (failure criteria is less than 80 percent). This was caused by the number of small aircraft and helicopters to skew the search blip-scan ratio lower.

5.2 ATCS EVALUATION TESTS.

5.2.1 Test Objectives.

The objective was to determine if the primary (ASR-8) and secondary (ATCBI-4) radars video data were of sufficient quality to be used for ATC.

NOTE

Lihue Terminal Radar Facility (LIH) video data could not be evaluated by the Honolulu CERAP (ZHN) ATCSs because the data will not be integrated into the CERAPs mosaic video data, until after the Lihue Terminal Radar Facility (LIH) is commissioned.

5.2.2 Test Criteria.

The primary (ASR-8) and secondary (ATCBI-4) radars video data were usable for ATC. There are not an excessive number of lost/coasting targets or other anomalies.

5.2.3 Test Description.

The Lihue FCT (LIH) ATCSs observed the primary (ASR-8) and secondary (ATCBI-4) data on their DBRITE displays.

NOTE

The video data presented on the DBRITE displays was not used for ATC, but only for familiarization and training.

5.2.4 Data Collection and Analysis Method.

There was only one Lihue FCT (LIH) ATCS who was radar qualified, therefore only one questionnaire was completed. The completed questionnaire was forwarded to the Test Director (TD) for evaluation. (See appendix G)

5.2.5 Results and Discussion.

Overall the video data were satisfactory. However the primary (ASR-8) and secondary (ATCBI-4) targets are weak close to the radar site. It should be noted, however, the Lihue Terminal Radar Facility (LIH) has not been commissioned yet, and is still being optimized.

5.3 HUMAN ENGINEERING TESTS.

5.3.1 Test Objectives.

The objective was to verify that AF Environmental Technicians could replace lamps in the AOL assembly and perform other required maintenance tasks on the FGAR Zenith Service Hatch Assembly mounted equipment.

5.3.2 Test Criteria.

Zenith Service Hatch Assembly mounted equipment, e.g., AOL lamps, etc., can be maintained.

5.3.3 Test Description.

An AF Environmental Technician: (1) climbed the web ladder to the Zenith Service Hatch Assembly, (2) opened the Zenith Service Hatch, (3) simulated replacement of the AOL lamps, and (4) climbed down the web ladder to the antenna platform.

5.3.4 Data Collection and Analysis Method.

The test was monitored by the Kauai AF SSC Supervisor and a second Environmental Technician. They then submitted the results of the test to the TD for evaluation.

5.3.5 Results and Discussion.

A rigid ladder was originally planned for the facility, but at the time of installation ESSCO determined a web ladder was the best type to use. The personnel at the Lihue Terminal Radar Facility (LIH) developed their own procedures for use of the web ladder.

6. FLIGHT CHECK.

The Western-Pacific Region had a commissioning flight check performed. The flight check was not a part of OT&E testing, but the results are included (see appendix H).

The flight check was performed on October 18 and 22, 1996, after the ESSCO had completed the installation and testing of the FGAR. The FAA flight check aircraft was a Rockwell International SabreLiner. The flight check data were recorded by the Honolulu CERAP (ZHN).

The flight check was performed with the primary radar (ASR-8) operating with only one channel and the antenna feed set for circular polarization (CP), this caused a degradation of the system performance. Data recorded before and after the flight check, with the primary radar (ASR-8) operating with both channels and the antenna feed set for linear polarization (LP), showed a marked improvement, the primary (ASR-8) blip/scan ratio sometimes exceeding that of the secondary (ATCBI-4) radar.

Beacon false targets were not a problem. One reflector was identified, but was reduced to approximately one error per day by adjustment of the systems Improved Side Lobe Suppression (ISLS). In addition, false targets produced by this reflector do not appear in any of the normal flight patterns.

Beacon splits averaged 0.5 to 0.7 percent, this is the normal rate for a CD-1, operating in a terminal environment.

7. CONCLUSIONS.

a. Electromagnetic performance testing without an FGAR and with the FGAR installed could not be accomplished. However, when the FGAR is used with an ASR and an ATCRBS it does not appear to effect their electromagnetic performance characteristics.

b. The results of OT&E Operational testing uncovered no major problems with the Type II FGAR when used with ASR and an ATCRBS.

8. RECOMMENDATIONS.

The Type II FGAR when used in a terminal environment meets the Operational Suitability and Operational Effectiveness requirements of the FAA. It is recommended that the Lihue Terminal Radar Facility (LIH) be integrated into the NAS.

9. ACRONYMS AND ABBREVIATIONS.

<	Less Than
%	Percent(age)
±	Plus/Minus
0 CODE	Zero Beacon Code Count (EQARS program)
ACP	Azimuth Change Pulse(s)
AOL	Aircraft Obstruction Light(s)
ARSR	Air Route Surveillance Radar
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATCBI	Air Traffic Control Beacon Interrogator
ATCRBS	Air Traffic Control Radar Beacon System
ATCBS 0000	ATCRBS Identification Code All Zeros (TRACS BFTS program)
ATCS	Air Traffic Control Specialist
AZMTH ERROR	Azimuth Error (TRACS TDR program)
BEACON HITS	Beacon Hit Count (TRACS TDR program)
BIT 25	Bit 25 Count (EQARS program)
BOS	Beacon Only Site
BPE	Beacon Permanent Echo (parrot)
BPE1	Beacon Permanent Echo #1 (parrot) [EQARS program]
BRTQC	Beacon Real-Time Quality Control (EQARS program)
CD	Common Digitizer
CERAP	Combined Center/Radar Approach Control
DBRITE	Digital Bright Radar Indicator Tower Equipment
DOWNLINK REF	Downlink Reflection (TRACS BFTS program)
DT&E	Developmental Test and Evaluation
EARTS	En Route Automated Radar Tracking System
EQARS	EARTS Quick Analysis of Radar Sites
ERMS	Environmental Remote Monitoring Subsystem
ESSCO	Electronic Space Systems Corporation (company name)
FAA	Federal Aviation Administration

FCT	Federal Contract Tower
FGAR	Fixed Ground Antenna Radome
GFE	Government Furnished Equipment
HI	Hawaii
ID	Identification (TRACS BFTS program)
ISLS	Improved Side Lobe Suppression
LIH	Lihue Federal Contract Tower (identifier)
LIH	Lihue Terminal Radar Facility (identifier)
LPS	Lightning Protection Subsystem
MPH	Miles Per Hour
M3/A %	Mode 3/A Validity Percentage (EQARS program)
M3/A REL	Mode 3/A Reliability (TRACS TDR program)
M3/A VAL	Mode 3/A Validity (TRACS TDR program)
MC %	Mode C Validity Percentage (EQARS program)
MC REL	Mode C Reliability (TRACS TDR program)
MC VAL	Mode C Validity (TRACS TDR program)
Mode S	Mode Select Beacon System
NAS	National Airspace System
NM	Nautical Mile(s)
NE	Nebraska
OT&E	Operational Test and Evaluation
PC	Personal Computer
PD	Probability of Detection
PE	Permanent Echo (TRACS TDR program)
PLOTCD	PLOTCD (TRACS program, not an acronym)
PPI	Planned Position Indicator (TRACS RRAP program)
PRF	Pulse Repetition Frequency
QJM	Rockville Beacon Only Site (identifier)
RADAR REINF	Search Reinforced Rate (TRACS TDR program)
RAR	Ring-A-Round (TRACS BFTS program)
RDAS	Radar Data Acquisition Subsystem

RMMS	Remote Maintenance Monitoring System
RR %	Radar Reinforced Percentage (EQARS program)
RRAP	Radar Recording and Analysis Program (TRACS program)
RTQC	Real-Time Quality Control (EQARS program)
SCANS	Scan Count (EQARS program)
SCH	Search (EQARS program)
SEARCH COLLIM	Search Collimination Rate (TRACS TDR program)
SLS	Side Lode Suppression
SPLIT	Target Split (TRACS BFTS program)
SSC	Service Support Center
STC	Sensitivity Time Control
STK	Radar Site Summary and Track Correlation Option (EQARS program)
SUM	Radar Site Summary Option (EQARS program)
TD	Test Director
TDR	TRACS Data Reduction (TRACS program)
TEMP	Test and Evaluation Master Plan
TRACS	Transportable Radar Analysis Computer System
UPLINK REF	Uplink Reflection (TRACS BFTS program)
VAC	Volts Alternating Current
VDC	Volts Direct Current
ZHN	Honolulu Combined Center/Radar Approach Control (identifier)

APPENDIX A

REPORT

REVIEW OF RADOME EM PERFORMANCE FOR

ASR-8 (S-BAND) AND (BI-4) L-BAND

AOS-230

SURVEILLANCE SYSTEMS ENGINEERING

Memorandum

US Department
of Transportation

Federal Aviation Administration

Subject: INFORMATION: Review of Radome EM Performance for ASR-8 (S-Band) and (BI-4) L-Band

Date: Sept. 29, 1995

From: Manager,
Surveillance Systems Engineering, AOS-230

Reply to Attn. of: Sanford
405-954-8012

To: Program Manager for Radome,
En Route Products, AND-440

We have received the additional information about the method of test used during the radome evaluation for the ASR-8 and BI-4 in Lihue, HI. The information indicates that our concerns were investigated and addressed during the testing of the radome.

AOS-230 does not have any other question about the radome installation and see no reason the radome should not be installed. The region will, however, need to initiate a local NCP to cover the installation of the radome.

If you have any other question please contact Bob Sanford at 405-954-8012.

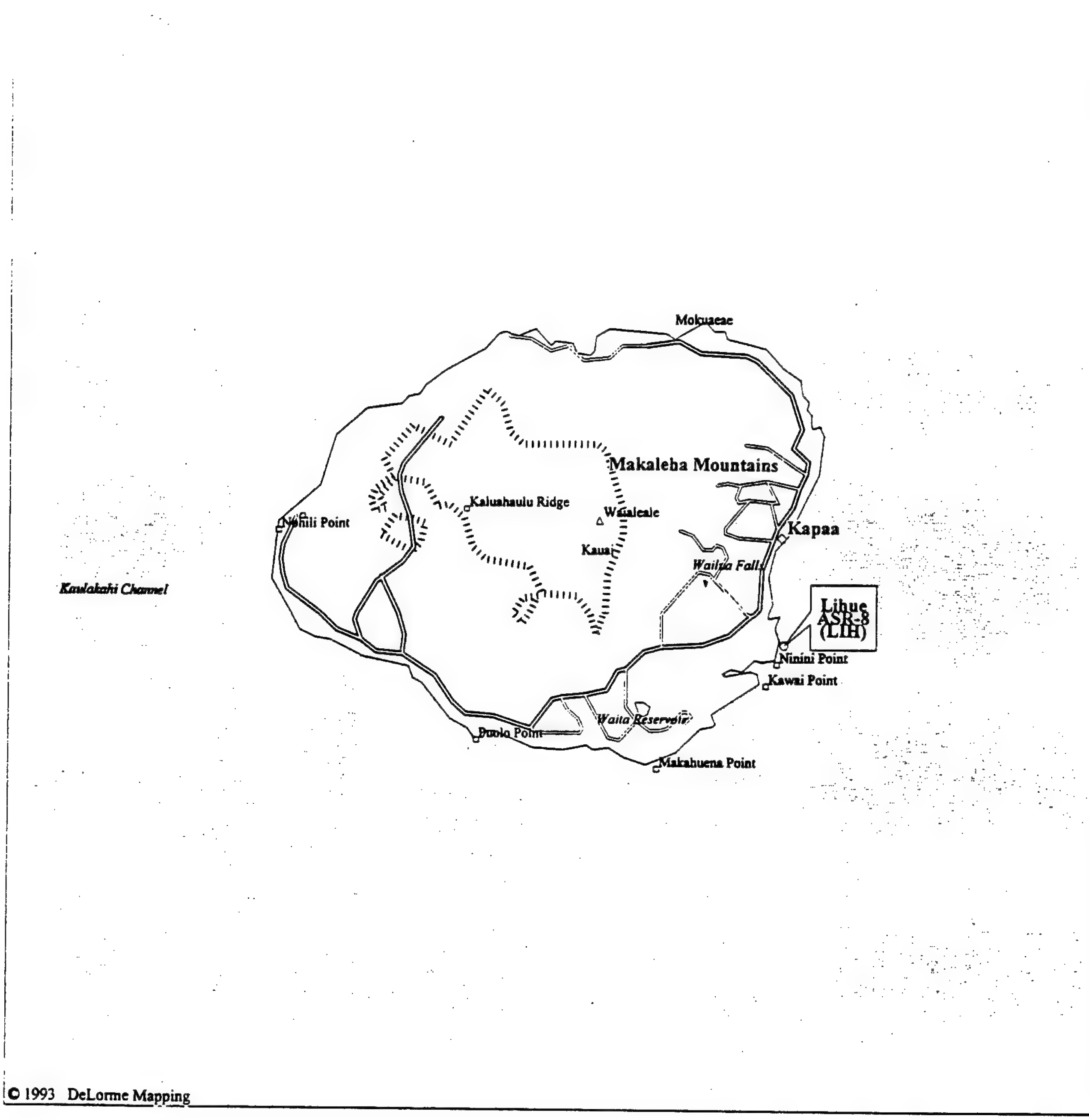
Joe Arguello

Joe Arguello

APPENDIX B

LOCATION MAPS

LIHUE TERMINAL RADAR FACILITY (LIH)



LEGEND

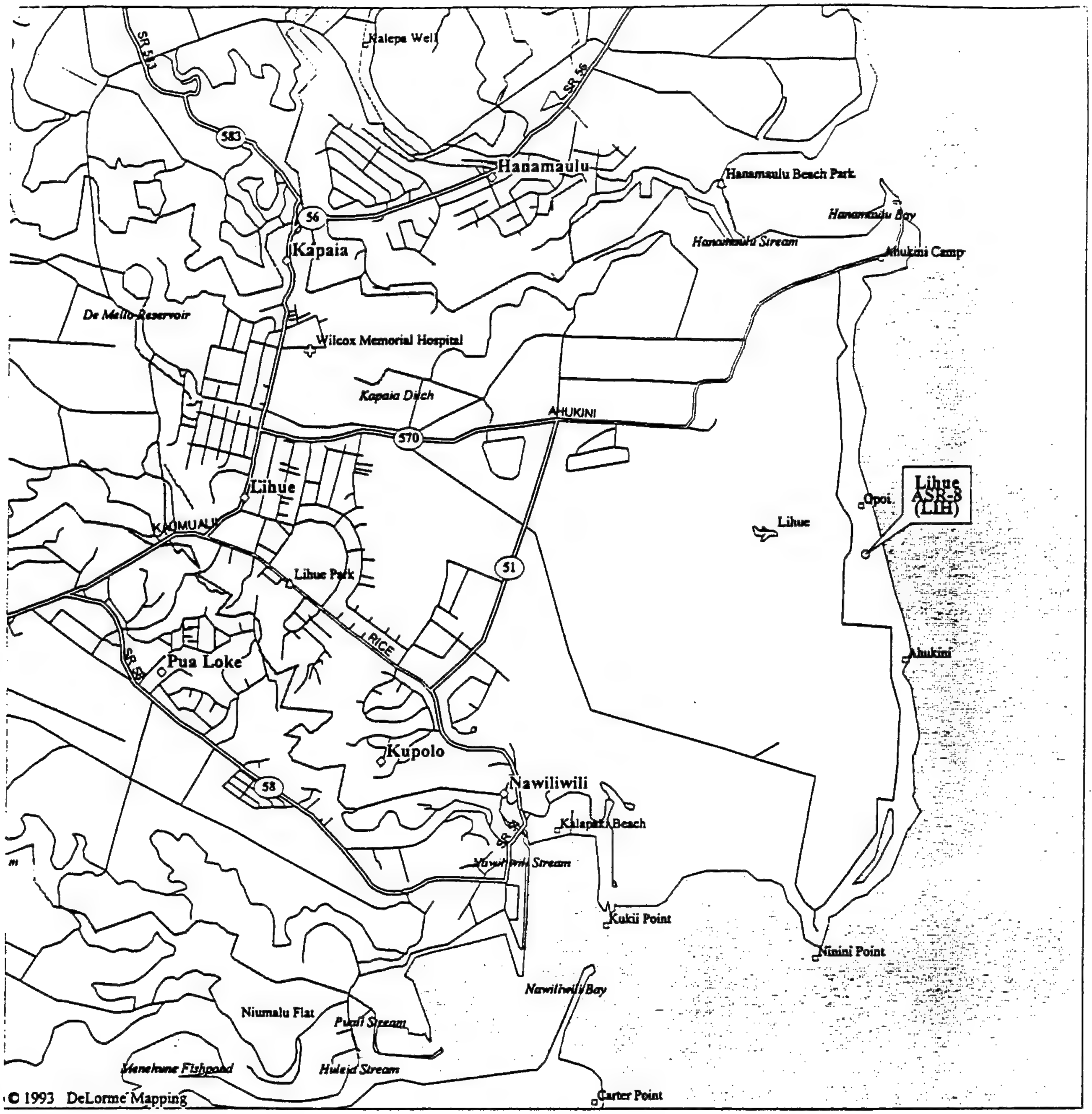
- Geo Feature
- Town, Small City
- Hill
- Major Street/Road
- State Route
- Land Mass
- Open Water
- Contour

Scale 1:500,000 (at center)

10 Miles

10 KM

Mag 10.00
Sun Oct 13 19:30:50 1996



LEGEND

- Population Center
- State Route
- Geo Feature
- Town, Small City
- Hospital
- Park
- Airfield
- Street, Road
- Major Street/Road
- State Route
- River
- Open Water
- Intermittent River
- Utility (powerline)

Scale 1:31,250 (at center)

2000 Feet

1000 Meters

Mag 14.00
Sun Oct 13 19:49:54 1996

APPENDIX C

TEST PARTICIPANTS

TEST PARTICIPANTS

The personnel, their title, and organization, who participated in the testing are listed below.

1. William J. Hughes Technical Center.

   Harold G. Sedgwick, FGAR Test Director, Senior Engineer, Vitro/ACT-310B

2. Honolulu CERAP SSC (ZHN).

   Geneson Coloma, RDAS Engineer

3. Lihue FCT (LIH).

   William Clark, ATCS

4. Kauai AF SSC (LIH).

   Jennifer K. Nakazawa, Kauai SSC Supervisor

   John A. Kruse, Electronic Technician

   David W. Mason, Electronic Technician

   Clifford K. Tsuyama, Environmental Technician

   Calvin S. Umetsu, Environmental Technician

APPENDIX D

DATA ANALYSIS PROGRAMS

DATA ANALYSIS PROGRAMS

The programs used to analyze the primary (ASR) and secondary (ATCRBS) radar electromagnetic performance data parameters are described below:

1. Beacon Extractor and Recorder (BEXR) Program.

The BEXR is a combination of two special boards mounted inside an International Business Machines (IBM) Corporation compatible personal computer (PC) and a software program, developed by the Sensis Corporation. The hardware/software combination provides: (1) the capability to capture and view the analog signal output of a beacon interrogator, (2) a real-time digitizer to extract beacon reply data, (3) the capability to record analog and digital beacon data, (4) the capability to playback recorded analog and digital data, (5) the capability to process digital beacon replies, and (6) the capability to analyze data and to generate various types of plots, which can be outputted to a printer.

2. EQARS Program - Radar Site Summary Option (SUM).

The EQARS Radar Site Summary Option (SUM) accumulates data to determine the operational status of selected radar sites. The data includes a Radar Summary Table and Deviation Distribution Table.

a. Radar Summary Table.

1. Scan Count (SCANS) - The scan count is the number of antenna revolutions completed while the SUM option is active.

2. Beacon (BEACON)/Search (SCH) Only Counts - The beacon/search-only counts are the number of beacon (beacon-only and radar-reinforced) and search-only reports detected while the SUM option is active.

3. Radar Reinforced Percentage (RR %) - The radar reinforced percentage is the percentage of beacon reports received that have the radar reinforced bit set.

4. Bit 25 Count (BIT 25) - The bit 25 count is the number of beacon messages received with bit 25 set. This indicates the report is separated from another beacon report at the same range on the basis of different Mode 3/A or C codes. The azimuth of this report may have a larger than normal error.

5. Zero Beacon Code Count (0 CODE) - The zero beacon code count is the number of beacon or radar-reinforced beacon reports received with a beacon code of all zeros.

6. Mode 3/A Validity Percentage (M3A %) - A validated Mode 3/A reply is counted when a beacon or radar-reinforced beacon hit is declared and the Mode 3/A validation bit is set.

7. Mode C Validity Percentage (MC %) - A validated Mode C reply is counted when a beacon or radar-reinforced beacon hit is declared and the Mode C validation bit is set.

b. Deviation Distribution Table.

1. Collimination.

(a) Azimuth Error - The azimuth deviation between merged and beacon only target returns. The azimuth error is given in one Azimuth Change Pulse (ACP) increments.

(b) Range Error - The range deviation between merged and beacon only target returns. The range error is given in 1/8 nautical mile (NM) increments.

2. Real-Time Quality Control (RTQC).

(a) Azimuth Error - The azimuth deviation between the RTQC targets actual position and its expected position. The azimuth error is given in one ACP increments.

(b) Range Error - The range deviation between the RTQC targets actual position and its expected position. The range error is given in 1/8 NM increments.

(c) Reliability Percentage (RELIABILITY) - The reliability for the beacon and search (ASR) radars represents the probability of receiving a good RTQC report for a given scan.

3. Permanent Echo (PE).

(a) Beacon Code - The code of the beacon reply received.

(b) Azimuth Error - The azimuth deviation between the PEs actual position and its expected position. The azimuth error is given in one ACP increments.

(c) Range Error - The range deviation between the PEs actual position and its expected position. The range error is given in 1/8 NM increments.

(d) Reliability Percentage (RELIABILITY) - The reliability for the beacon and search (primary) radars represents the probability of receiving a good reply from the PE for a given scan.

3. Transportable Radar Analysis Computer System (TRACS) Program.

a. PLOTCD Program.

The PLOTCD program provides the capability to plot and sort aircraft and weather data in a polar presentation on a IBM compatible PC graphics display. The PLOTCD program is run on a TRACS PC.

b. Radar Recording and Analysis Program (RRAP).

The RRAP program will record data from an ASR-9, Air Route Surveillance Radar (ARSR)-3, Mode S, or CD-1/2, on an IBM compatible PC, with a special multiplexer board installed. In addition, it can process live primary (ASR/ARSR) and secondary (ATCRBS) radar data. It will output to either tabular list or graphic plots to a printer or PC display.

1. Tabular List - Tabular list data available are: (1) interpreted messages, (2) sorted beacon codes, (3) snapshot, and (4) file summary. (Beacon code sort and file summary are not available for real-time data analysis.)

2. Graphic Plot - Graphic plot data available are: (1) planned position indicator (PPI), and (2) a plot of altitude versus range.

c. TRACS Data Reduction (TDR) Program.

1. Probability of Detection (PD).

(a) Beacon - The percentage of the track life that a beacon message correlates to the track. The PD in this case equals percentage detected or blip/scan ratio.

NOTE

Track life is the number of antenna scans from track start to track stop, including both the start and stop scans. No messages are lost and the four coasts that led to a track drop are not counted.

(b) Search - Usually if a search report correlates to a beacon message, the beacon message is flagged as radar reinforced. Sometimes the CD will output a beacon message that is not reinforced due to the fact that there is no search report. On occasion, a non-reinforced beacon message will be accompanied by a search message that is close enough in range and azimuth to match or collimate with the beacon message. (Search PD = [number of radar reinforced beacon messages + number of mis-colliminated search messages + number of coasts with search message in window] ÷ track life)

(c) Total - If either the search message or a beacon message occurs in the scan, it is called a hit. (Total PD = number of hits ÷ track life)

2. Mode 3/A Reliability (M3/A REL) - If the tracked targets code changes, the program makes a determination whether or not the code change was caused by the pilot changing the code. If caused by the pilot, the new code should remain the same for a period of time. If the code changes and then returns to the original code, the code would be classified not reliable for those scans that the code was different. (M3/A REL = number of reliable codes received ÷ number of beacon messages received)

3. Mode 3/A Validity (M3/A VAL) - The CD flags all beacon messages as validated or not validated. Validation usually occurs when the message is composed of at least two consecutive replies containing the same code. (M3/A VAL = number of messages received with the validity bit set ÷ number of beacon messages received)

4. Mode C Reliability (MC REL) - The EARTS tracking program predicts the next scans target position, including its altitude. If the message deviates from expected altitude by a specified amount, the altitude is declared not reliable. (MC REL = number of reliable altitude codes received ÷ number of beacon messages received)

5. Mode C Validity (MC VAL) - The CD flags all beacon messages as validated or not validated. Validation usually occurs when the message is composed of at least two consecutive replies containing the same code. (MC VAL = number of messages received with the validity bit set ÷ number of beacon messages received)

6. Beacon Hit Count (BEACON HITS) - Each beacon message contains a hit count field. This number is derived by subtracting the start azimuth from the stop azimuth. This number is affected by the transmitter power, receive reply signal strength, receiver sensitivity time control (STC) curves, transmitter pulse repetition frequency (PRF), antenna beam width, transmitter sidelobe suppression (SLS) operation, position of the aircraft in the antenna beam, the aircraft range and altitude, and CD settings.

7. Search Reinforced Rate (RADAR REINF) - Each beacon message can be flagged with a search reinforced bit. Reinforcement depends on search detection and search collimation. (RADAR REINF = number of beacon messages with reinforced bit set ÷ number of beacon messages received)

8. Search Collimation Rate (SEARCH COLLIM) - A search target should be collimated with a beacon target whenever the search message lies within a certain delta azimuth from the beacon message. If collimation occurs, the beacon message will be tagged reinforced. The program looks at each beacon message that does not have the reinforced bit set, and tries to find a search message close enough so that it should have been colliminated by the CD. Any search message that should have reinforced a beacon message is declared mis-collimated. (SEARCH COLLIM = number of radar reinforced messages ÷ [number of radar reinforced beacon messages + number of mis-collimated search messages])

9. Range Error (RANGE ERROR) - Average value of the absolute value of the range difference between the correlated beacon message and the EARTS operational program tracking routines prediction in NM.

10. Azimuth Error (AZMTH ERROR) - Average value of the absolute value of the azimuth difference between the correlated beacon message and the EARTS operational program tracking routines prediction in degrees.

d. Beacon False Target Summary (BFTS).

1. Total Number of False Target Reports - The total number of beacon false target replies received.

2. Total Number of Discrete Code Target Reports - The total number of beacon discrete codes received.

3. <u>False Target Report Percentage</u> - The percentage of beacon false target replies received. (FALSE TARGET REPORT PERCENTAGE = [total number of false target reports X 100] ÷ total number of discrete code target replies)

4. <u>Target Split (SPLIT)</u> - Total number of beacon target replies with a: (1) delta range of 0.2 NM or less, or (2) a delta azimuth of 4 degrees or less, from another target reply. (TARGET SPLIT PERCENTAGE = [total number of beacon replies declared a SPLIT X 100] ÷ total number of discrete code target replies)

5. <u>Ring-A-Round (RAR)</u> - Total number of beacon target replies with a: (1) delta range of 0.2 NM or less, or (2) a delta azimuth greater than 4 degrees, from another target reply. (RAR PERCENTAGE = [total number of beacon replies declared a RAR X 100] ÷ total number of discrete code target replies)

6. <u>Downlink Reflection (DOWNLINK REF)</u> - Total number of beacon target replies with a: (1) delta range greater than 0.2 NM, or (2) a delta azimuth of 4 degrees or less, from another target reply. (DOWNLINK REF PERCENTAGE = [total number of beacon replies declared a DOWNLINK REF X 100] ÷ total number of discrete code target replies)

7. <u>Pulse Repetition Frequency (PRF)</u> - Total number of beacon target replies with a: (1) delta range greater than 2 NM, or (2) a delta azimuth of 4 degrees or less, from another target reply. (PRF PERCENTAGE = [total number of beacon replies declared a PRF X 100] ÷ total number of discrete code target replies)

8. <u>Uplink Reflection (UPLINK REF)</u> - Total number of beacon target replies with a: (1) delta range greater than 0.2 NM or delta azimuth greater than 4 degrees, from another target reply, (2) both targets have valid beacon ATCRBS identification (ID) code, (3) ATCRBS ID code not valid, (4) altitude required or both targets have valid altitude and delta altitude is within user limits, or (5) speed available for a real target. (UPLINK REF PERCENTAGE = [total number of beacon replies declared an UPLINK REF X 100] ÷ total number of discrete code target replies)

9. <u>Other</u> - Total number of false beacon target replies not declared a SPLIT, RAR, DOWNLINK REF, PRF, or UPLINK REF. (OTHER PERCENTAGE = [total number of false beacon replies declared an OTHER X 100] ÷ total number of discrete code target replies)

10. <u>ATCRBS ID Code All Zeros (ATCRBS 0000)</u> - Total number of beacon target replies with a code of all zeros (0000). (ATCRBS ID 0000 PERCENTAGE = [total number of beacon replies with code of 0000 X 100] ÷ total number of discrete code target replies)

APPENDIX E

HONOLULU CERAP (ZHN)

EQARS AND TRACS DATA

HONOLULU CERAP EQARS DATA FOR LIHUE ASR-8 (LIH)

DATE		11/5/96	11/6/96	11/7/96	11/8/96	11/12/96	11/13/96	11/14/96	11/15/96
	FAIL CRITERIA				Note 1		Note 2		
Scans		221	481	651	557	617	670	653	457
Beacon		1231	2241	3209	4305	1837	2652	2370	1608
Sch Only		12082	13995	14740	5562	29890	32740	3755	27701
RR %	<80%	79.5	84.2	86.1	82.4	88.0	86.9	82.7	80.4
Bit 25	##	2	0	14	81	2	4	4	4
0 Code	##	6	3	16	148	1	9	8	4
M3A %	##	99.3	99.5	99.2	93.6	99.8	99.4	99.4	99.4
MC %	##	99.2	99.1	98.9	97.0	99.5	99.0	99.2	99.3
COLLIMINATION									
Azimuth Error	##	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
Range Error	##	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
RTQC									
Beacon									
Azimuth Error	##	-3.0	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9	-2.9
Range Error	##	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0
Reliability	<98%	100.0	100.0	100.0	100.0	100.0	91.1	100.0	100.0
Search									
Azimuth Error	+/- 4 ACP	+0.2	+0.2	+0.2	+0.2	+0.2	+0.0	+0.0	+0.2
Range Error	+/- 1/4 nm	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0
Reliability	<80%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
PERMANENT ECHO	BPE1								
Beacon Code	1275	1275	1275	1275	1275	1275	1275	1275	1275
Azimuth Error	+/- 2 ACP	+0.2	+0.3	+0.5	+0.5	+0.5	+0.5	+0.5	+0.5
Range Error	+/- 1/8 nm	+1.0	+1.0	+1.0	+1.0	+1.0	+1.0	+1.0	+1.0
Reliability	<90%	100.0	100.0	99.8	100.0	100.0	91.0	100.0	100.0
PRIMARY CHAN					B	B	B	B	B
PRIMARY POLARIZATION					CP	CP	CP	CP	LP
BEACON CHAN					B	B	B	B	B

HONOLULU CERAP EQARS DATA FOR LIHUE ASR-8 (LIH) (Continued)

DATE		11/18/96	11/19/96	11/21/96	11/22/96	11/25/96	11/26/96	11/27/96
	FAIL CRITERIA	Note 3					Note 4	Note 5
Scans		607	386	560	850	687	671	447
Beacon		2005	802	1106	2027	3491	4378	2045
Sch Only		8007	45107	60489	84895	24352	46489	11316
RR %	<80%	77.5	86.0	83.6	83.7	81.0	82.3	80.2
Bit 25	##	9	0	0	2	58	25	2
0 Code	##	61	3	3	2	23	40	1
M3A %	##	96.2	99.6	99.9	99.7	98.7	98.2	99.7
MC %	##	97.8	99.2	99.7	99.6	98.1	98.3	99.2
COLLIMINATION								
Azimuth Error	##	-0.1	+0.0	-0.1	-0.1	-0.1	-0.1	-0.2
Range Error	##	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
RTQC								
Beacon								
Azimuth Error	##	-3.0	-2.7	-2.9	-2.9	-3.0	-3.0	-2.9
Range Error	##	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0
Reliability	<98%	99.5	100.0	100.0	100.0	99.8	100.0	99.7
Search								
Azimuth Error	+/- 4 ACP	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2	+0.2
Range Error	+/- 1/4 nm	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0	+0.0
Reliability	<80%	100.0	100.0	100.0	100.0	100.0	100.0	100.0
PERMANENT ECHO	BPE1							
Beacon Code	1275	1275	1275	1275	1275	1275	1275	1275
Azimuth Error	+/- 2 ACP	+0.6	+0.4	+0.5	+0.5	-2.1	-2.0	-1.9
Range Error	+/- 1/8 nm	+1.0	+1.0	+1.0	+1.0	+1.0	+1.0	+1.0
Reliability	<90%	100.0	100.0	100.0	100.0	99.8	100.0	100.0
PRIMARY CHAN		B	A	A	A	A	A	A
PRIMARY POLARIZATION		LP	LP	LP	LP	LP	LP	LP
BEACON CHAN		B/A	B	B	B	B	A	A

HONOLULU CERAP TRACS DATA FOR LIHUE ASR-8 (LIH)

DATE		11/5/96	11/6/96	11/7/96	11/8/96	11/12/96	11/13/96	11/14/96	11/15/96
	FAIL CRITERIA				Note 1		Note 2		
TDR RESULTS									
Probability Detect									
Beacon	<90%	98.97	99.17	99.64	97.48	99.17	98.33	99.50	99.80
Search	<80%	73.60	79.96	79.15	81.09	73.85	79.78	74.38	71.38
Total		99.52	100.00	99.92	99.40	99.96	99.88	99.90	99.95
M3/A Rel	<98%	99.94	100.00	99.90	97.45	99.88	99.97	99.77	99.95
M3/A Val	<95%	99.94	99.86	99.66	96.05	99.96	99.85	99.80	99.80
MC Rel	<98%	99.88	99.86	99.56	97.76	99.84	99.85	99.90	99.85
MC Val	<92%	99.57	99.17	99.15	96.65	99.72	99.23	99.63	99.45
Beacon Hits		52.2	50.6	56.1	53.7	55.1	56.3	54.3	57.5
Radar Reinf	<80%	62.82	68.82	71.80	73.41	66.31	70.74	65.23	62.23
Search Collim	##	85.11	86.12	90.71	90.38	90.00	88.91	87.72	87.19
Range Error	##	0.055	0.055	0.056	0.078	0.053	0.056	0.053	0.051
Azimuth Error	##	0.201	0.213	0.237	0.282	0.235	0.228	0.228	0.229
BFTS RESULTS									
Total # Fls Tgt Rep		1	5	17	61	9	10	7	4
Total # Discrete Rep		1518	2757	3414	4585	2467	3216	2908	1884
Fls Tgt Rep %	##	0.07	0.18	0.50	1.33	0.36	0.31	0.24	0.21
Split		1	5	11	31	5	9	4	4
Split %	##	0.07	0.18	0.32	0.68	0.20	0.28	0.14	0.21
Ringaround		0	0	0	0	0	1	0	0
Ringaround %	##	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00
Downlink Ref		0	0	6	28	3	0	0	0
Downlink %	##	0.00	0.00	0.18	0.61	0.12	0.00	0.00	0.00
PRF		0	0	0	0	0	0	0	0
PRF %	##	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uplink Ref		0	0	0	2	0	0	2	0
Uplink Ref %	##	0.00	0.00	0.00	0.04	0.00	0.00	0.07	0.00
Other		0	0	0	0	1	0	1	0
Other %	##	0.00	0.00	0.00	0.00	0.04	0.00	0.03	0.00
ATCRBS ID 0000		0	2	16	148	1	9	9	4
ATCRBS ID 0000 %	##	0.00	0.07	0.41	2.96	0.04	0.28	0.30	0.20

HONOLULU CERAP TRACS DATA FOR LIHUE ASR-8 (LIH) (Continued)

DATE		11/18/96	11/19/96	11/21/96	11/22/96	11/25/96	11/26/96	11/27/96
	FAIL CRITERIA	Note 3					Note 4	Note 5
TDR RESULTS								
Probability Detect								
Beacon	<90%	99.10	99.65	99.52	99.73	98.89	98.30	99.55
Search	<80%	77.96	66.08	67.04	69.19	75.04	81.59	74.79
Total		99.82	100.00	100.00	99.96	99.53	99.80	99.92
M3/A Rel	<98%	99.67	99.47	100.00	100.00	99.82	99.47	99.96
M3/A Val	<95%	98.92	99.91	100.00	99.96	99.48	99.04	99.88
MC Rel	<98%	99.23	99.56	99.88	99.96	99.62	99.51	99.96
MC Val	<92%	98.24	99.65	99.82	99.73	98.61	98.43	99.35
Beacon Hits		55.9	55.9	57.3	56.1	54.3	52.5	56.0
Radar Reinf	<80%	67.16	57.74	57.32	59.59	68.27	71.90	66.20
Search Collim	##	86.17	87.53	85.70	86.17	90.75	88.25	88.66
Range Error	##	0.056	0.048	0.048	0.045	0.056	0.058	0.055
Azimuth Error	##	0.253	0.208	0.227	0.204	0.312	0.236	0.237
BFTS RESULTS								
Total # Fls Tgt Rep		15	1	10	9	14	21	4
Total # Discrete Rep		2507	1116	1683	2201	3284	4731	2358
Fls Tgt Rep %	##	0.60	0.09	0.59	0.41	0.43	0.44	0.17
Split		11	1	10	9	12	20	4
Split %	##	0.44	0.90	0.59	0.41	0.37	0.42	0.17
Ringaround		0	0	0	0	0	0	0
Ringaround %	##	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Downlink Ref		3	0	0	0	2	0	0
Downlink %	##	0.12	0.00	0.00	0.00	0.06	0.00	0.00
PRF		1	0	0	0	0	0	0
PRF %	##	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Uplink Ref		0	0	0	0	0	0	0
Uplink Ref %	##	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other		0	0	0	0	0	1	0
Other %	##	0.00	0.00	0.00	0.00	0.00	0.02	0.00
ATCRBS ID 0000		60	3	0	1	23	40	1
ATCRBS ID 0000 %	##	2.11	0.26	0.00	0.04	0.51	0.80	0.04

HONOLULU CERAP EQARS AND TRACS DATA LEGEND

NOTES:

1. High number of merge, 0000 codes, splits, and downlinks due to military exercise northeast of Kauai.

2. BRTQC and BPE1 out of tolerance because CD fault/alarm stopped beacon processing.

3. High number of 0000 codes due to switching to Beacon Channel A. (Problem with defruitter.)

4. High number of 0000 codes and BIT 25 due to military training mission northeast of Kauai.

5. Primary radar placed in simplex, LP prior to data collection. Channel B found to be causing high data counts resulting in time in storage bits being set.

Value not specified in Order 6190.10.

APPENDIX F

REPORT

LIHUE, HI (LIH) ASR-8 FIXED GROUND ANTENNA RADAR EVALUATION

HAWAII-PACIFIC SMO

Memorandum

U.S. Department
of Transportation
**Federal Aviation
Administration**

Hawaii-Pacific SMO
6700 Kalanianaole Hwy., Ste. 111
Honolulu, Hawaii 96825-1277

Subject: **INFORMATION**: Lihue, HI (LIH) ASR-8 Fixed Ground Antenna Radar Evaluation

Date: DEC 27 1996

From: Manager, Hawaii-Pacific SMO

Reply to Attn. of:

To: Associate Program Manager for Test, ACT-310B

Reference your memorandum, subject: Collection of Data in Support of FGAR OT&E Operational Testing of the Lihue Terminal Radar Facility, dated June 27, 1996.

Data collected between the period September 11 through November 27, 1996 was evaluated to characterize the operation of the primary and secondary radar systems at the newly established facility on Kauai. This data included recordings taken during the commissioning flight check on October 10-22, 1996. Evaluation of the flight check data is similar to those reported in James Masingill's ASR-8 Flight Check Report.

Flight check results indicate that Air Traffic will be satisfied with the performance of the radar system. High altitude primary radar coverage (above 20,000 feet) was non existent. However, the ASR-8 was not designed to provide high altitude coverage and radar coverage indicator charts for the ASR-8 in the flight check configuration supports the flight check results.

The Lihue radar passes all EQARS/TRACS9 radar analysis summaries except for radar reinforcement rate (64.62%) and search blip-scan (72.65%) because of the air traffic environment around Lihue. The low number of aircraft per scan causes the beacon parrot to skew the reinforcement rate and the number of small aircraft/helicopter to skew the search blip-scan lower.

While the evaluation shows that the Lihue radar performs adequately, further study at another site of performance before and after radome installation may be required to see effect of the radome on radar performance.

If you require additional information, please contact Geneson Coloma, RDAS, at (808) 739-7251.

Thomas A. Smith

Attachments

Copy to: HNL CERAP

APPENDIX G

ATCS EVALUATION QUESTIONNAIRE

LIHUE FCT (LIH)

ATCS EVALUATION QUESTIONNAIRE
LIHUE TERMINAL RADAR FACILITY (LIH)
TYPE II FGAR OT&E OPERATIONAL TEST

Test Number: LHAT-1

Test Title: Lihue ATCT (LIH) ATCS Evaluation Test

Test Site: Lihue Terminal Radar Facility (LIH)

Evaluator's Name: WILLIAM CLARK

PART I - PRIMARY RADAR EVALUATION

1. How well are the primary targets being detected (displayed), i.e., are there target drops; or are targets not being detected: (1) in certain areas, (2) at certain altitudes, or (3) as the range of the target increases?

YES/NO (circle one)

Comments: STC IS BEING WORKED ON, TARGETS ARE WEAK CLOSE IN

2. Do the primary track trajectories change, i.e., are they following a straight or arched path smoothly, or do they appear to be shifting back and forth in azimuth from scan to scan?

YES/NO (circle one)

Comments:

3. Are there primary false targets? If so: (1) at what range(s) and azimuth(s), and (2) do they appear at undesirable locations?

YES/NO (circle one)

Comments:

4. Are the primary Permanent Echoes (PE) at the correct range and azimuth?

YES/NO (circle one)

Comments: NONE IDENTIFIED -

FGAR-2(LIH)/II

PART II - SECONDARY (BEACON) RADAR EVALUATION

1. How well are the beacon targets being detected (displayed), i.e., are there target drops and coasts; or are targets not being detected: (1) in certain areas, (2) at certain altitudes, or (3) as the range of the target increases?

   YES/NO (circle one)

   Comments: Beacon targets displayed satisfactorily outside the MTI area. Seems to be weak close in. To be fair, the equipment is not been declared operational, and perhaps the ~~technicians are still working to correct samed.~~

2. Do the beacon track trajectories change, i.e., are they following a straight or arched path smoothly, or do they appear to be shifting back and forth in azimuth from scan to scan?

   YES/NO (circle one)

   Comments: Targets are following what appears to be the intende course for the approaches being flown.

3. Are there beacon false targets? If so: (1) at what range(s) and azimuth(s), and (2) do they appear at undesirable locations?

   YES/NO (circle one)

   Comments: No false targets noted, during periods of evaluating

4. Are the beacon Permanent Echoes (PE) or "parrot(s)" at the correct range and azimuth?

   YES/NO (circle one)

   Comments: VORTAC and DOME site appear to be at correct positions.

If you have any questions concerning this questionnaire or the Fixed Ground Antenna Radome (FGAR) Program, contact Leonard H. Baker, ACT-310B, at (609) 485-5353 or fax (609) 485-5995, or at the FAA Technical Center's, Communications/Navigation/Surveillance Engineering and Test Division, Atlantic City International Airport, New Jersey 08405.

Thank you for taking your time to provide us with this valuable information.

FGAR-2(LIH)/II

APPENDIX H

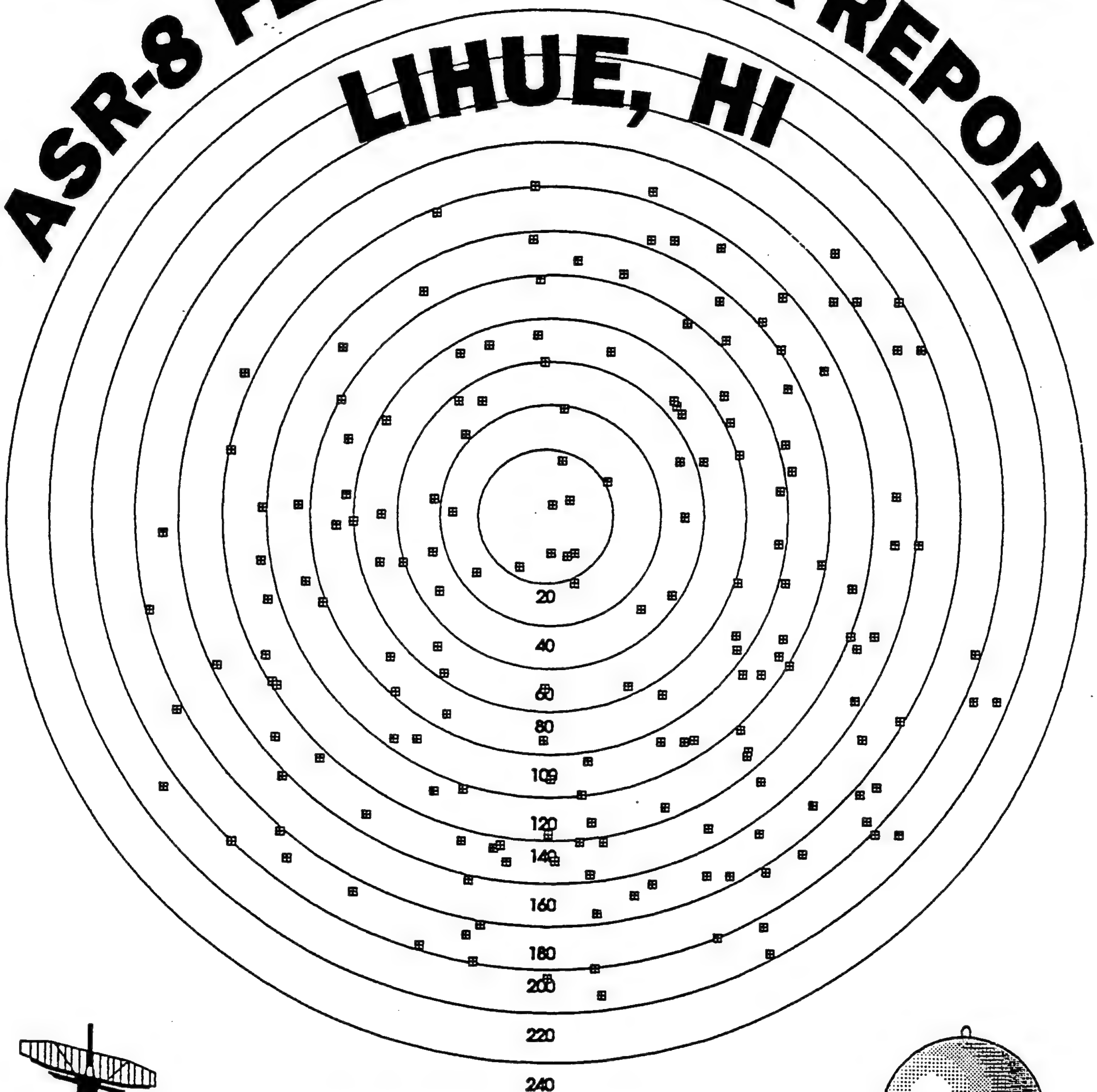
REPORT

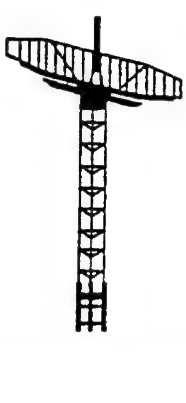
ASR-8 FLIGHT CHECK REPORT

LIHUE, HI

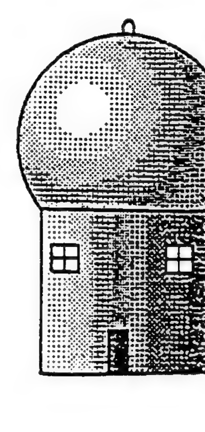
ASR-8 FLIGHT CHECK REPORT

LIHUE, HI





THIS REPORT PRODUCED
BY JAMES W. MASINGILL



To: Mr. Hai Nguyen

Author: Mr. Jim Masingill

Subject: Flight Check ASR-8, Lihue Hi. 18, 22 Oct. 1996.

The flight check was flown on the 18th and 22nd of October in three separate flights The first flight was flown to check the various fixes in the coverage area, the second flight was a short segment to test the coverage in the northwest quadrant. The third flight was flown on Tuesday the 22nd and was used to test the inner and outer fringe coverage. Plots of the segments of the flights are on the following pages with a description of the coverage and analysis of the reasons for any loss of coverage. On the portions of the flight where data was lost and, appeared to be screening, an analysis was done using topographical maps to determine if screening was in fact the problem since no panoramic photos were available from the present radar site location.

The equipment at the site was configured in accordance with the flight check manual and the direction of the flight check coordinator in Honolulu. The following equipment configurations were used.

Beacon	Channel 1 Active	Power set to 50 watts at the antenna. (One dB from 62 watt commissioning Power) ISLS
Search	Channel A Active Channel B Off-line (Single Channel operation <u>NOT</u> in diversity.)	Circular Polarization
Common Digitizer CD-1 A&B	Both CD1s Operational	Ace 3 and Runlength discrimination on for search. Search Lead Edge=10 Trail Edge=8 Beacon Lead Edge=6 Beacon Trail Edge=2 Beacon Begin Validate=2 Run length reporting on.
Flight Check A/C (Saber Liner)		Low Sense (-69db) and Low Power

The following snapshots of the flights were taken using PLOTCD, RRAP, and the BEXR. The BEXR recordings are included to explain the loss of CD data during the periods of data loss. Only two BEXR snapshots are used due to the inability of the BEXR software to filter the flight check aircraft from the other traffic. All loss of data was caused by the aircraft not receiving the interrogation. This was determined by lack of any replies during the periods of data loss. Loss of data due to Beacon Interrogator sensitivity is normally indicated when replies are spotty. A more detailed discussion is included with each figure.

Also included are QARS (Quality Analysis Radar Summary) including summaries of data recorded with the system operating in normal day to day operation. These are included to demonstrate the large difference in the radar's performance from worst case to best case operation.

In summary, the beacon coverage during the flight check was adequate, however the search coverage was marginal. The Search was severely degraded through the use of single channel, circular polarization. During recordings made before and after the flight check with the radar in diversity and linear polarization the search blip scan approached and sometimes exceeded the beacon blip scan. Coverage for this facility during normal day to day operation will be excellent. On degraded days when the facility is having to be operated in circular polarization the search coverage will be marginal. This should not be a problem as the radar will be operated in linear polarization on most days.

Beacon false targets were not a problem. One reflector was identified but the use of ISLS reduced the number of false targets to about 1 per day. Also any false targets caused by this reflector do not appear in in any flight paths. Beacon splits averaged .5 to.7% this is a normal rate for the CD-1 in the terminal environment and should not cause any problems with air traffic.

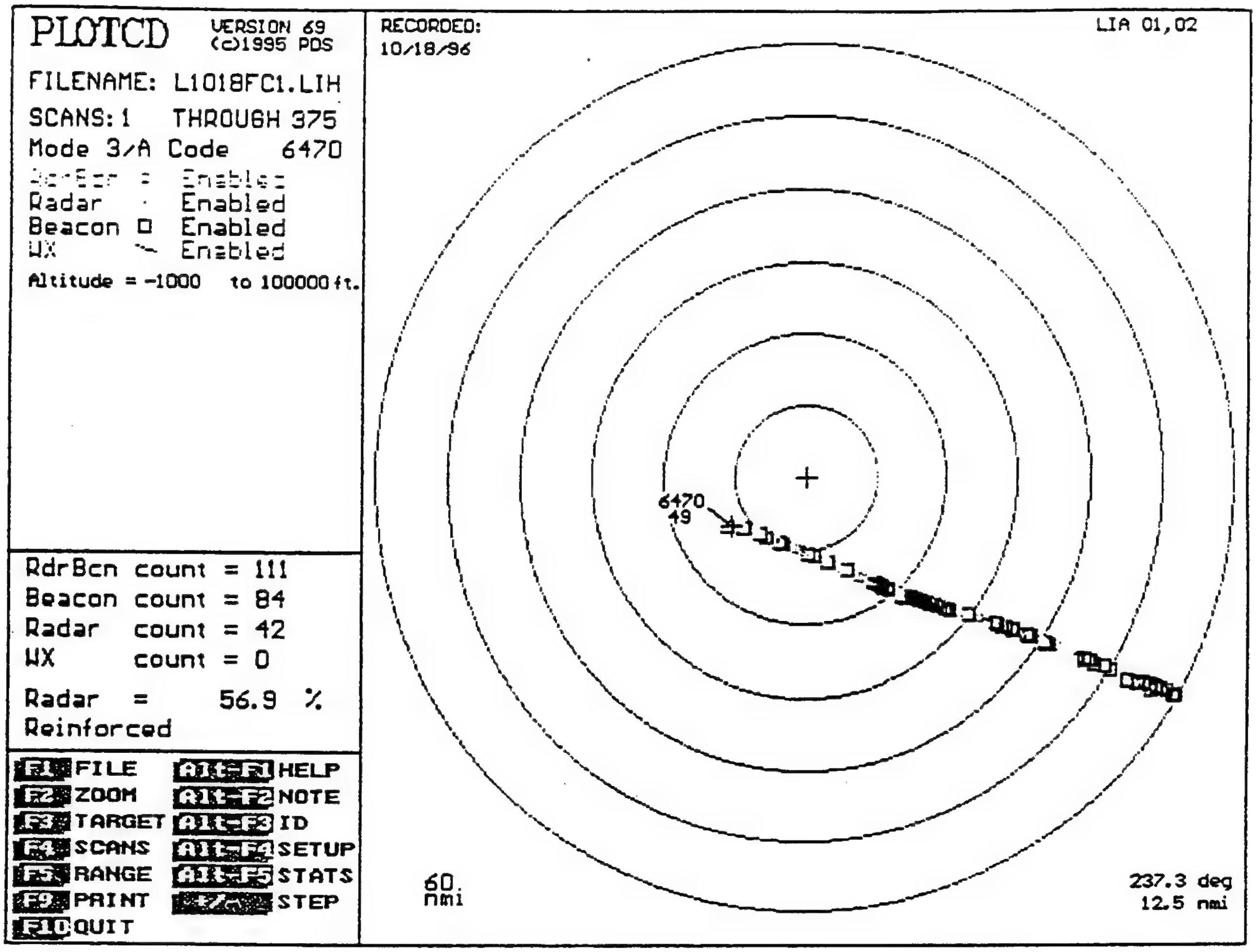


Figure 1
CD-1A

Reference Figures 1 Through 3. This is the first segment of the first flight check. Figure 1 is from CD-1A and Figure 2 is from CD-1B. Figure 3 is from the BEXR. This segment was flow from Honolulu to the SOK VOR, the flight was flown with a beacon mode 3 code of 6470 and was flown at an altitude of 4900 ft. There was loss of data during the first portion of the flight. It appears that there is some lobeing which caused the loss of data. This can be seen in figure 3 the plot of the target replies. It appears that this is only a problem with marginal transponders (simulated by the flight check a/c's transponder being in low sensitivity). Other A/C flying in the same area did not experience this problem.

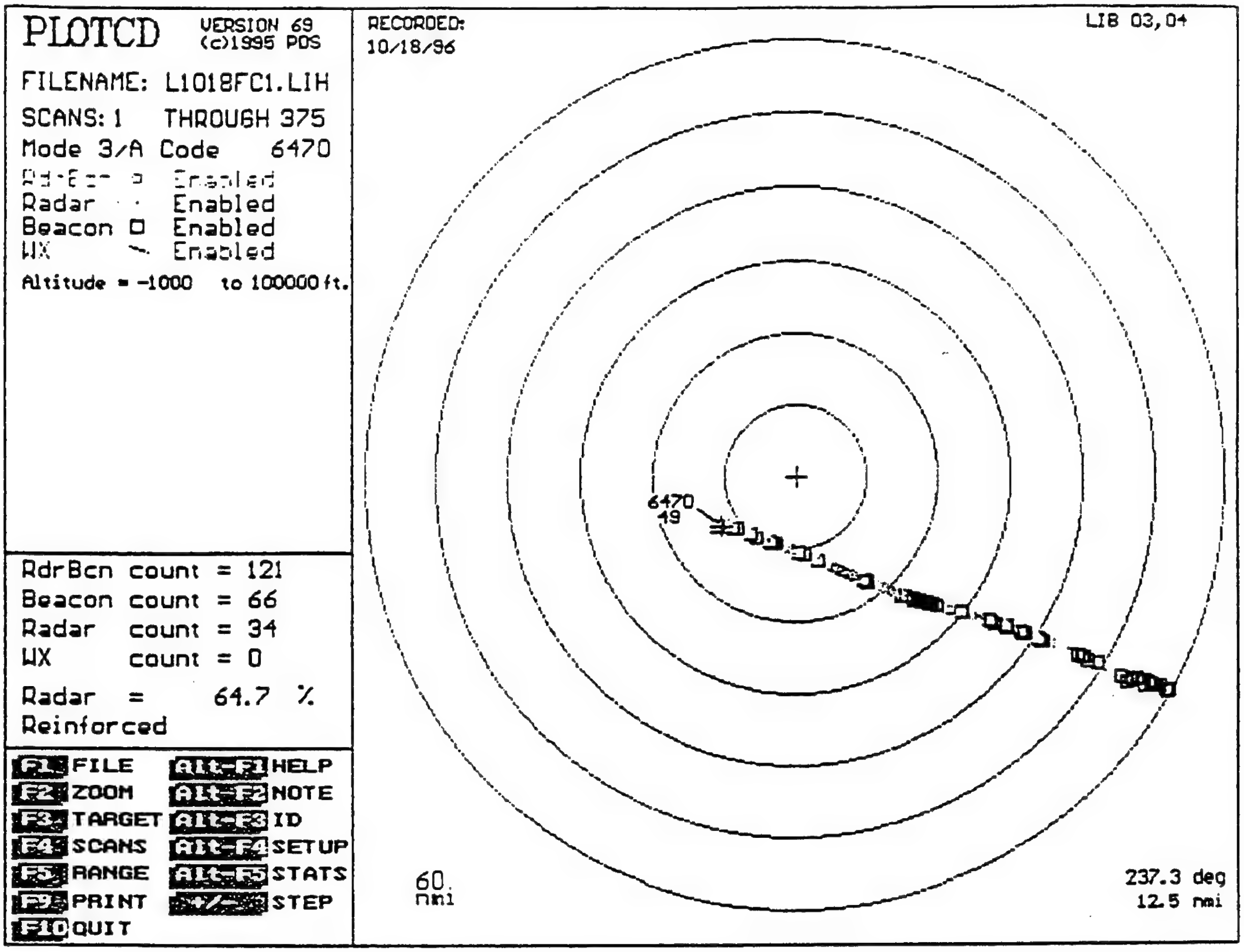


Figure 2
CD-1B

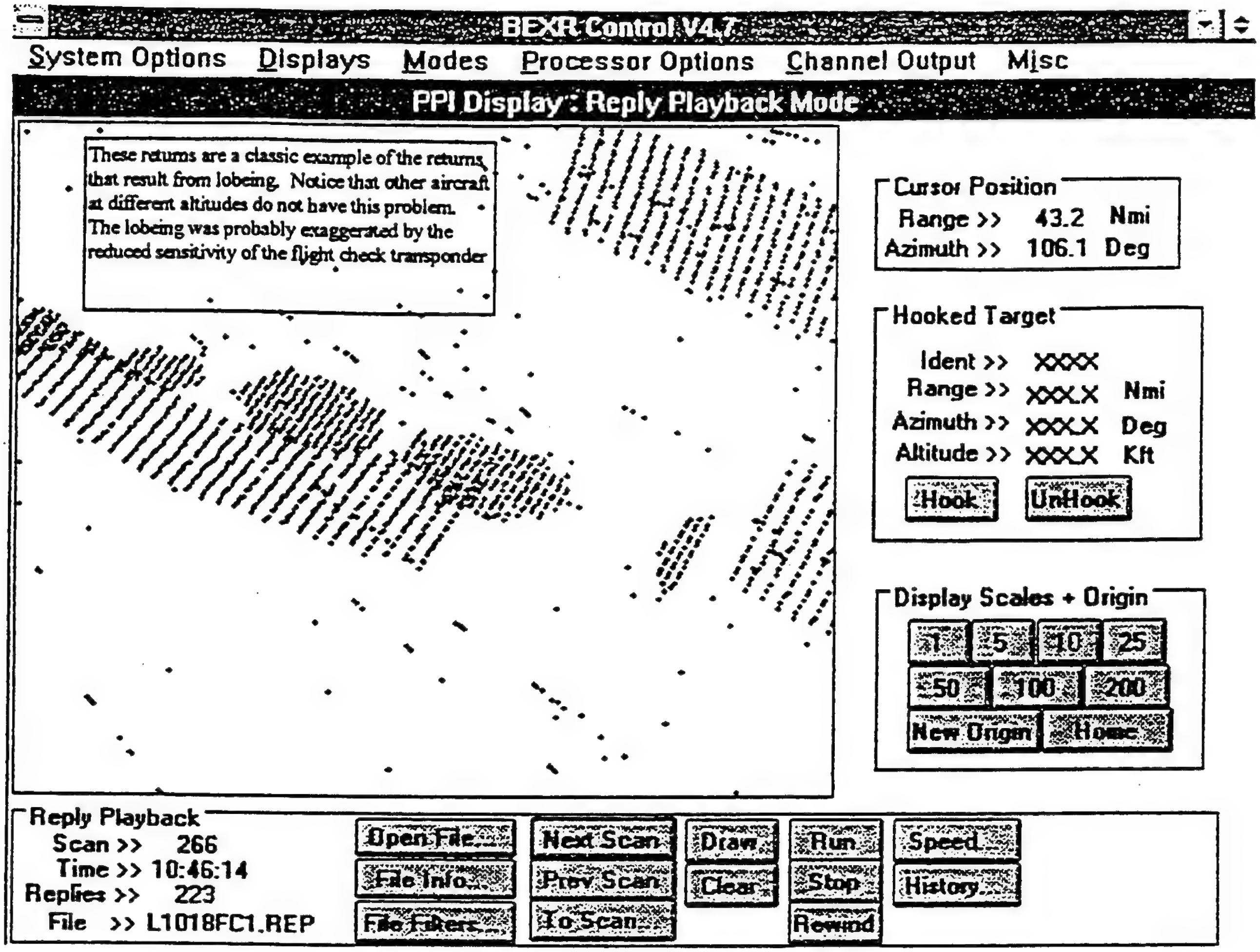


Figure 3
BEXR

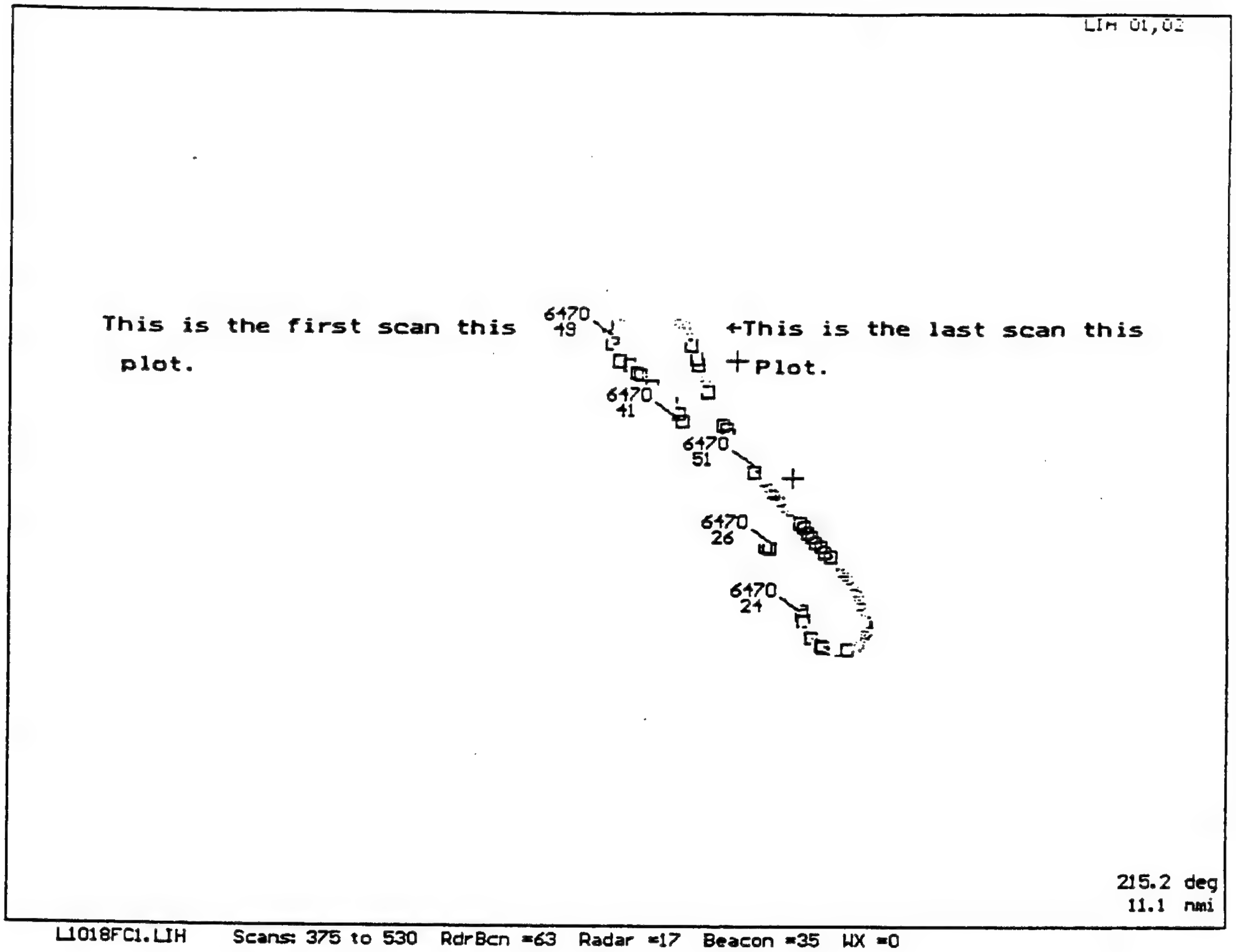


Figure 4
CD-1A

Reference figures 4 and 5(CD-1 A and CD-1 B respectfully). This portion of the flight was flow from the SOK VOR in an area southwest of the radar facility This was flown to check the screening caused by the mountains southwest of the radar. This area was flow twice at the same altitudes with the same results.

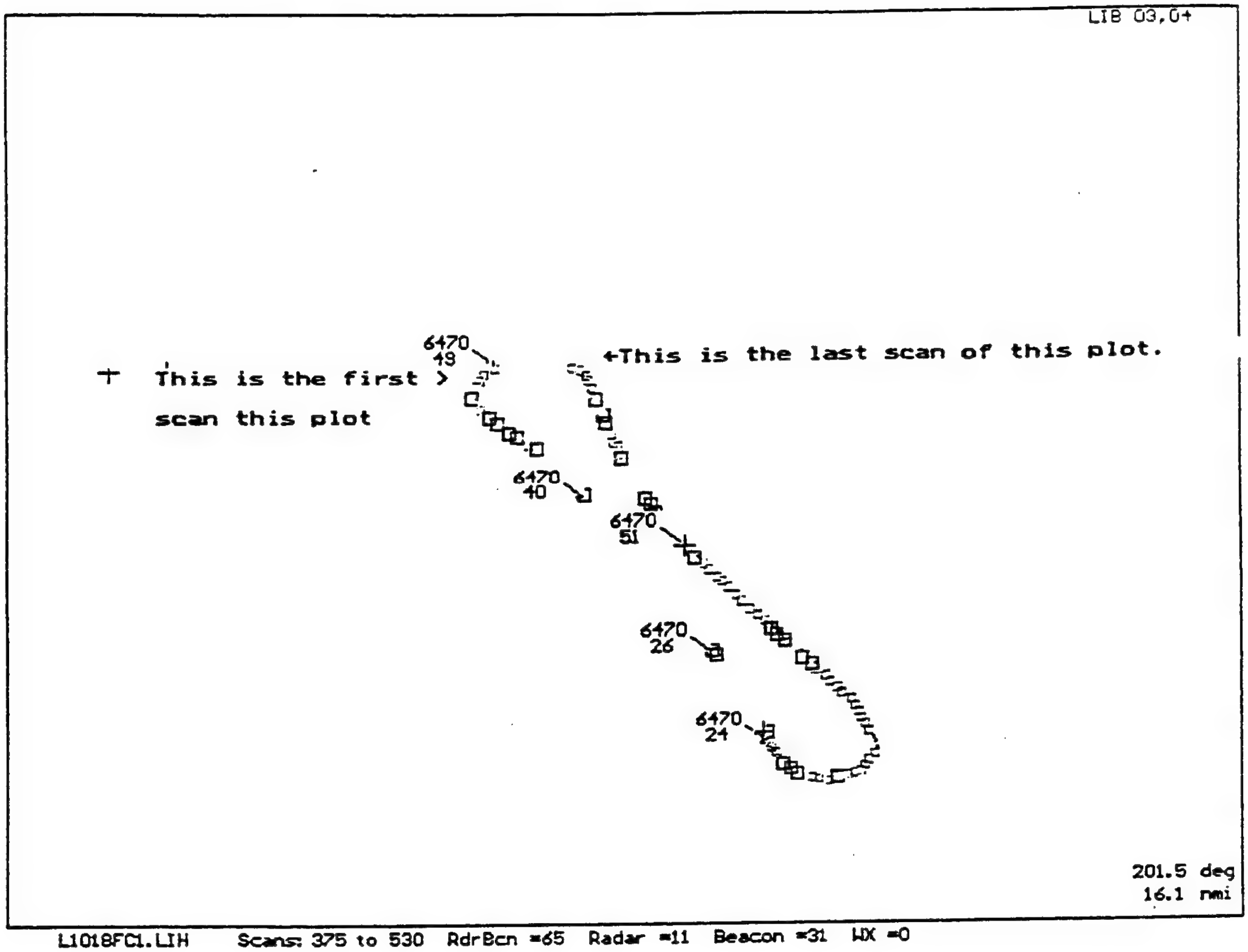


Figure 5
CD1-B

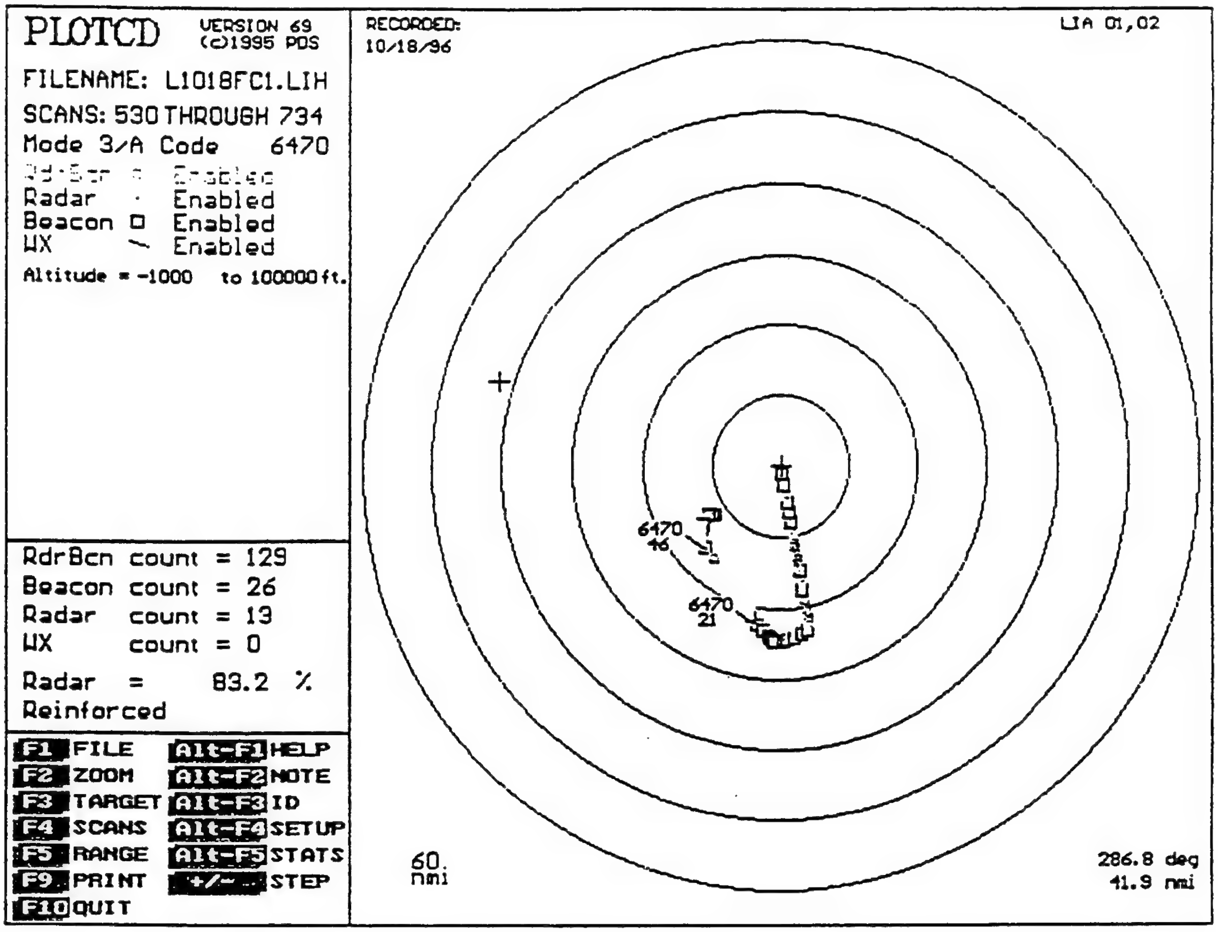


Figure 6
CD-1A

Reference Figures 6 and 7. This is the second portion of the area southwest of the radar continuing on to the airport. The data losses were the same as the first part of this segment. Upon approach to Lihue, airport the flight check aircraft descended to 100 ft and performed a touch and go. Data was lost one nautical mile from the radar. This loss was approximately 1/4 NM from the end of the runway.

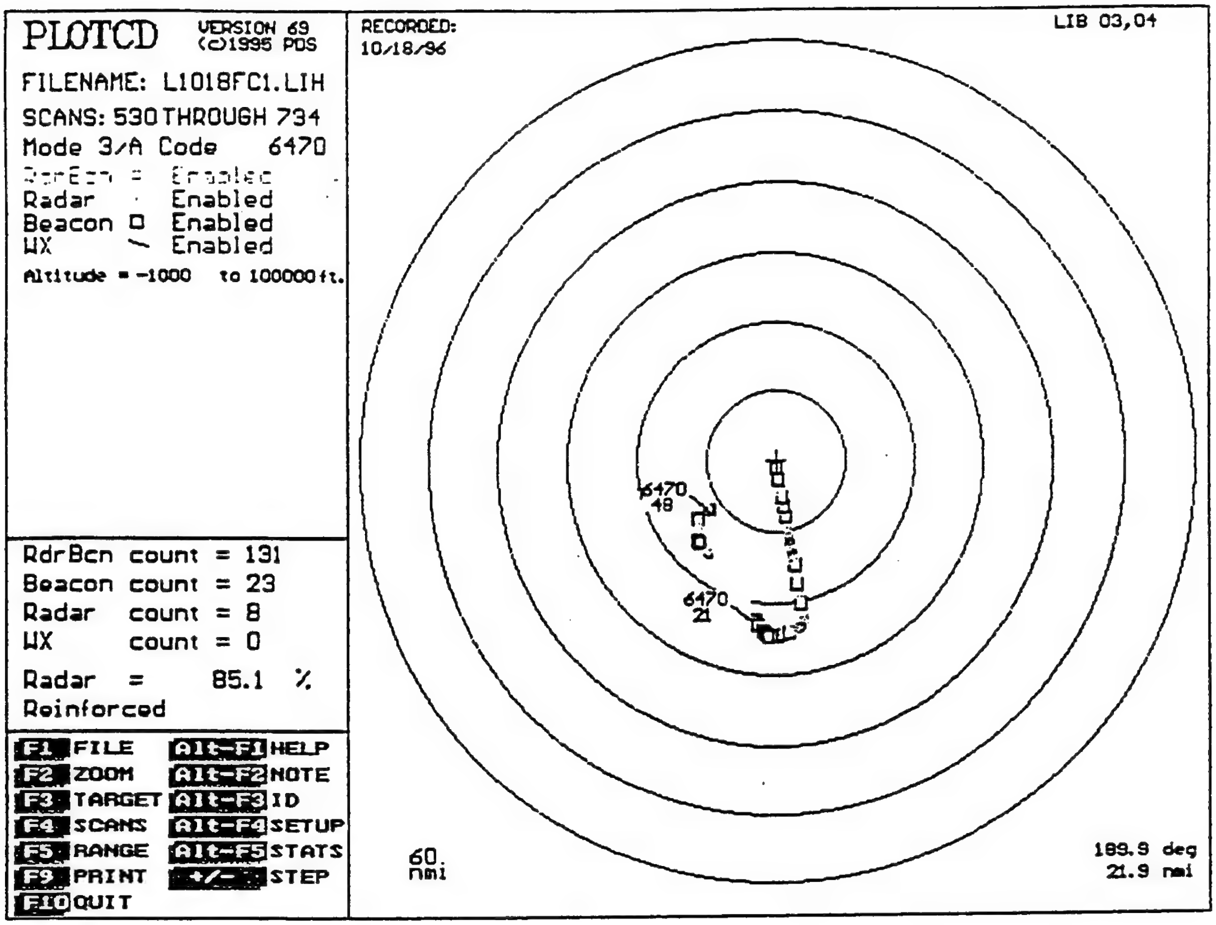


Figure 7
CD-1B

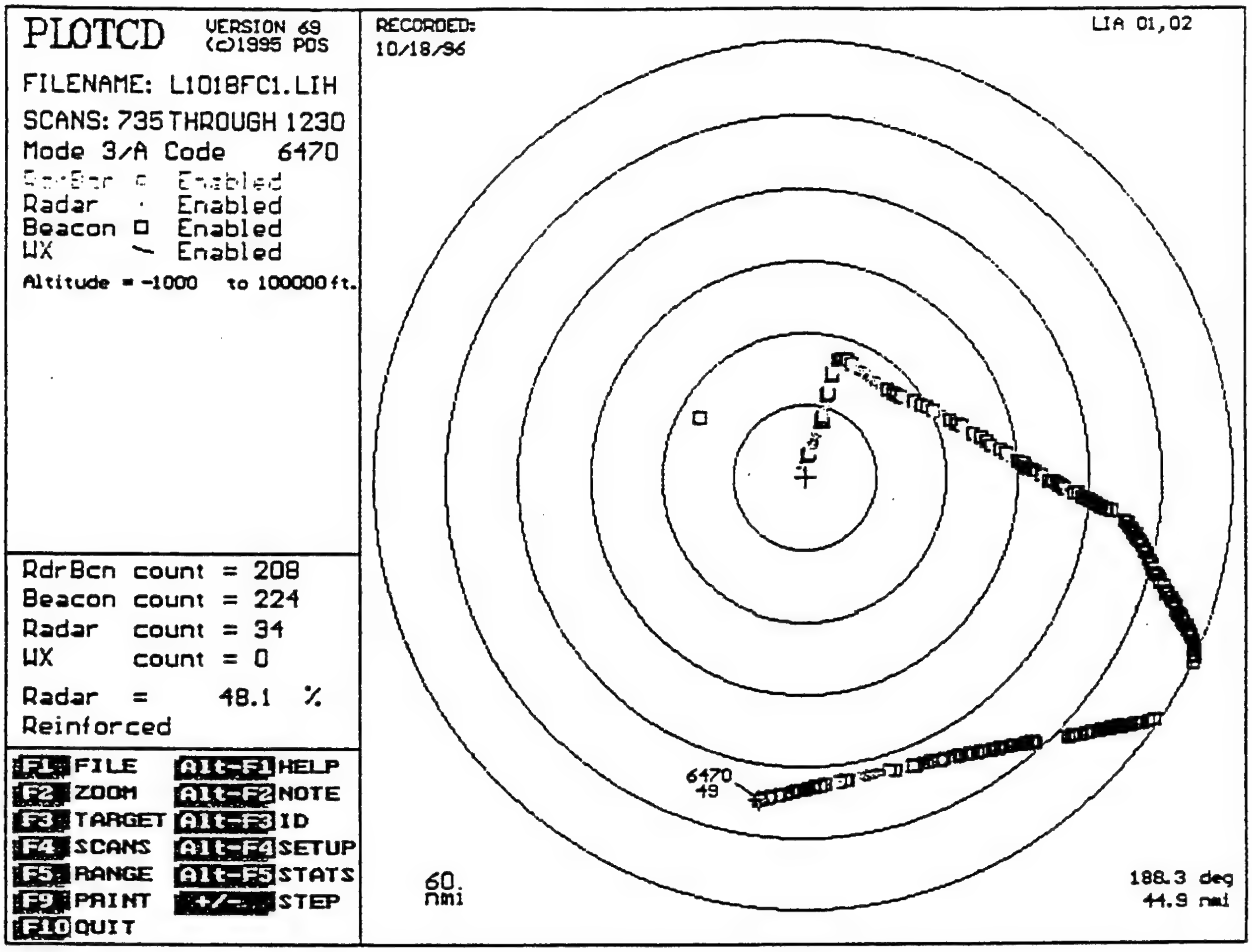


Figure 8
CD-1A

Reference figures 8 through 10. This segment was flown from the radar site north to the FRANKR intersection, southeast to the PATSY intersection, continuing to the HAULE intersection, south to the BROOKE intersection and then west to the LEANE intersection. This portion of the flight went very well. The only problems were during the turn at the HAULE intersection and a short loss of data during the last leg of the segment. This data loss appears to be caused by the same lobeing effect that caused the loss of data during the first portion of the flight the BEXR plot, Figure 10 shows the replies from the aircraft during the period of data loss. Near the LEANE intersection the flight check aircraft was lost completely. This was caused by the screening from the mountains southwest of the radar site. The minimum altitude that and aircraft can be expected to be picked up at the LEANE intersection is approximately 10,000 ft MSL.

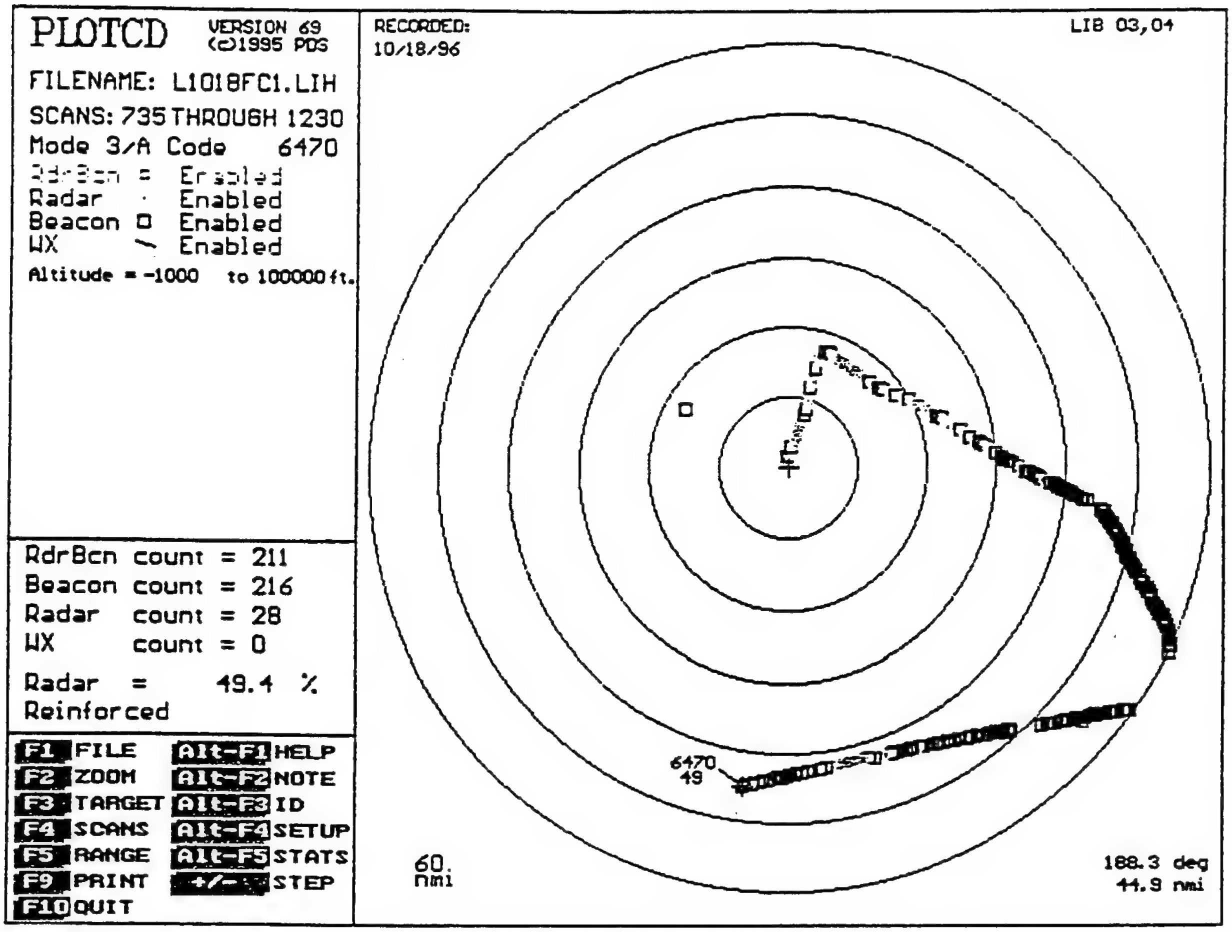


Figure 9
CD-1B

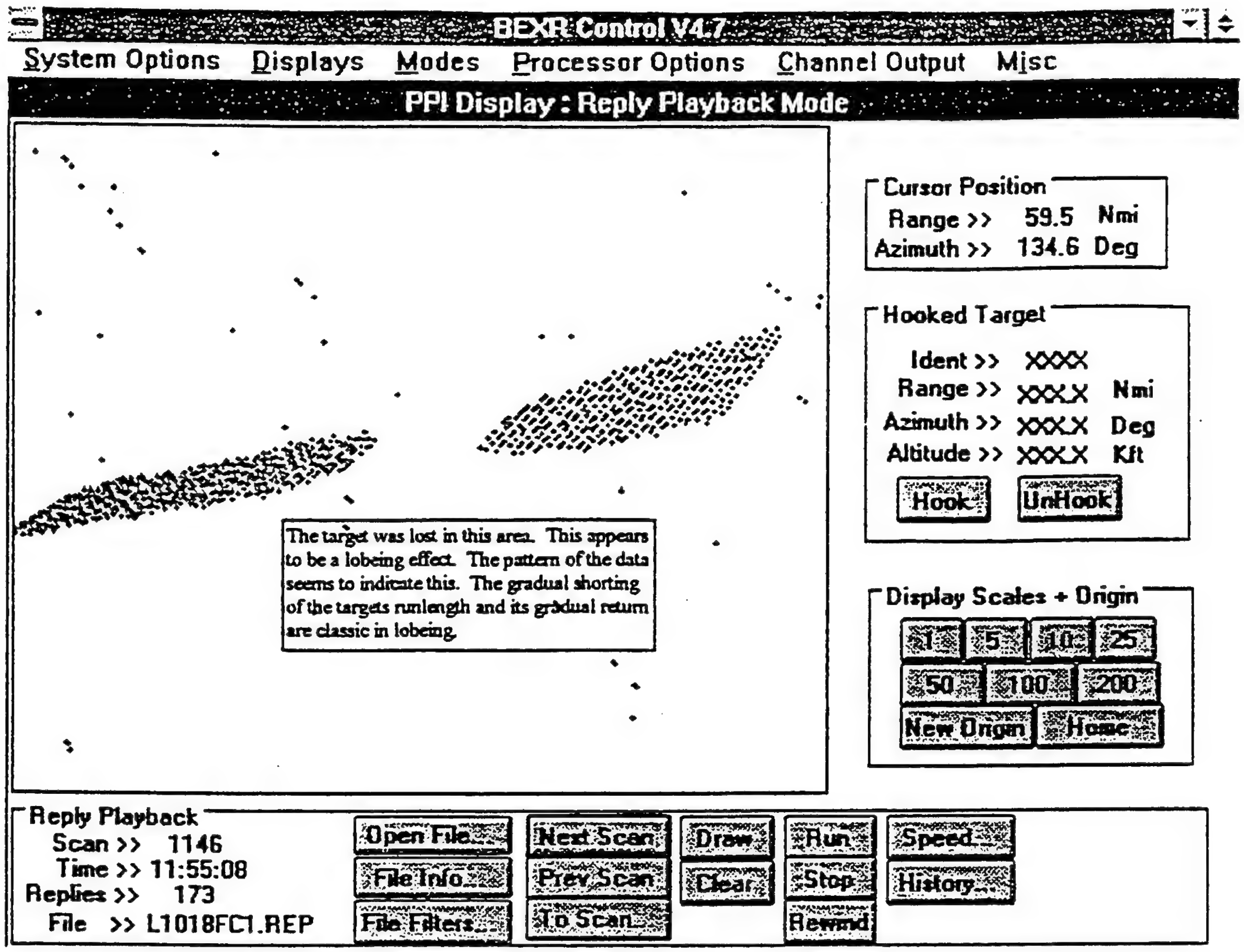


Figure 10
BEXR

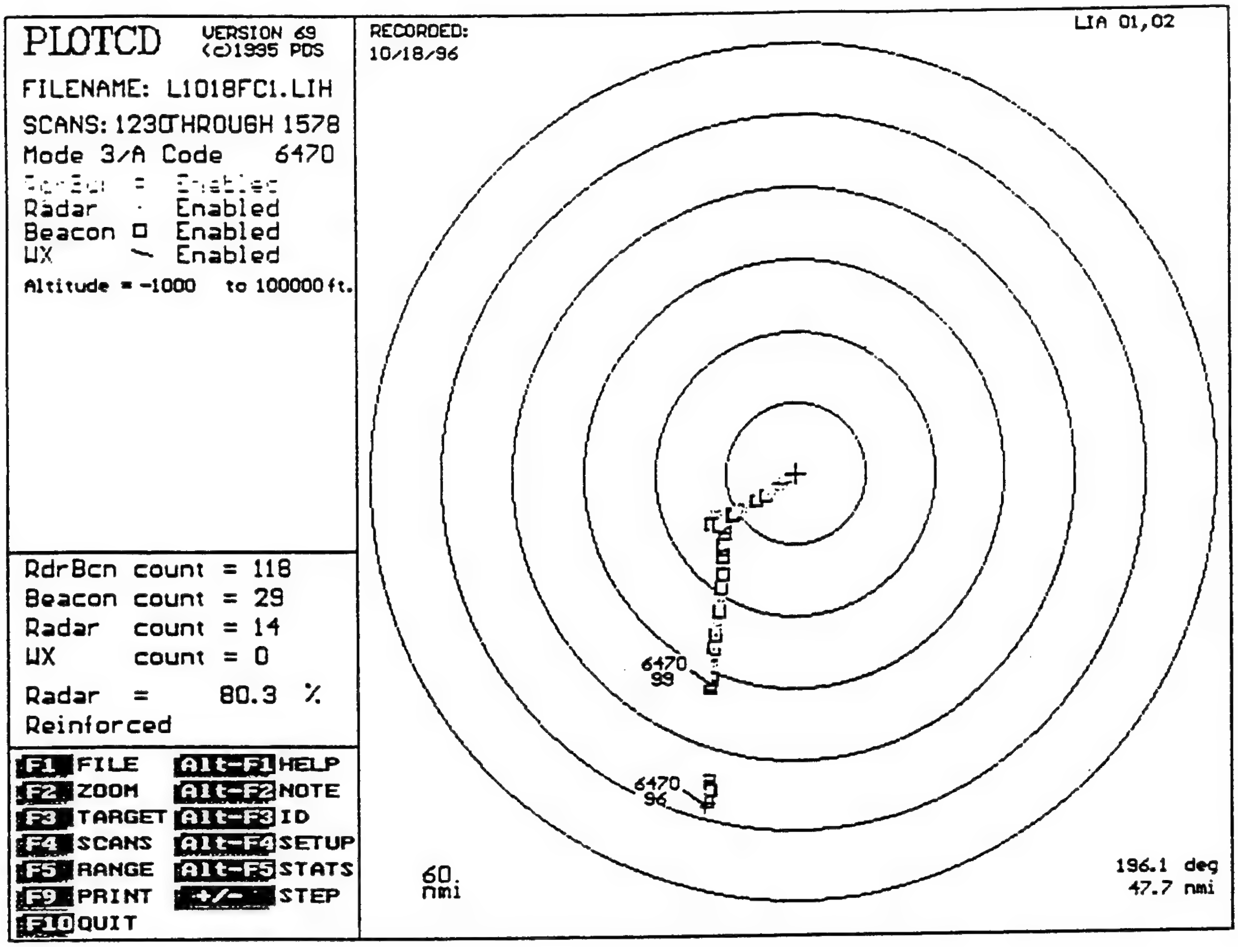


Figure 11
CD-1A

Reference figures 12 and 13. This segment was flown from the LEANE intersection to the SOK VOR and then to the radar site. Screening, by the mountains, on the east coast of Kauai caused the data loss.

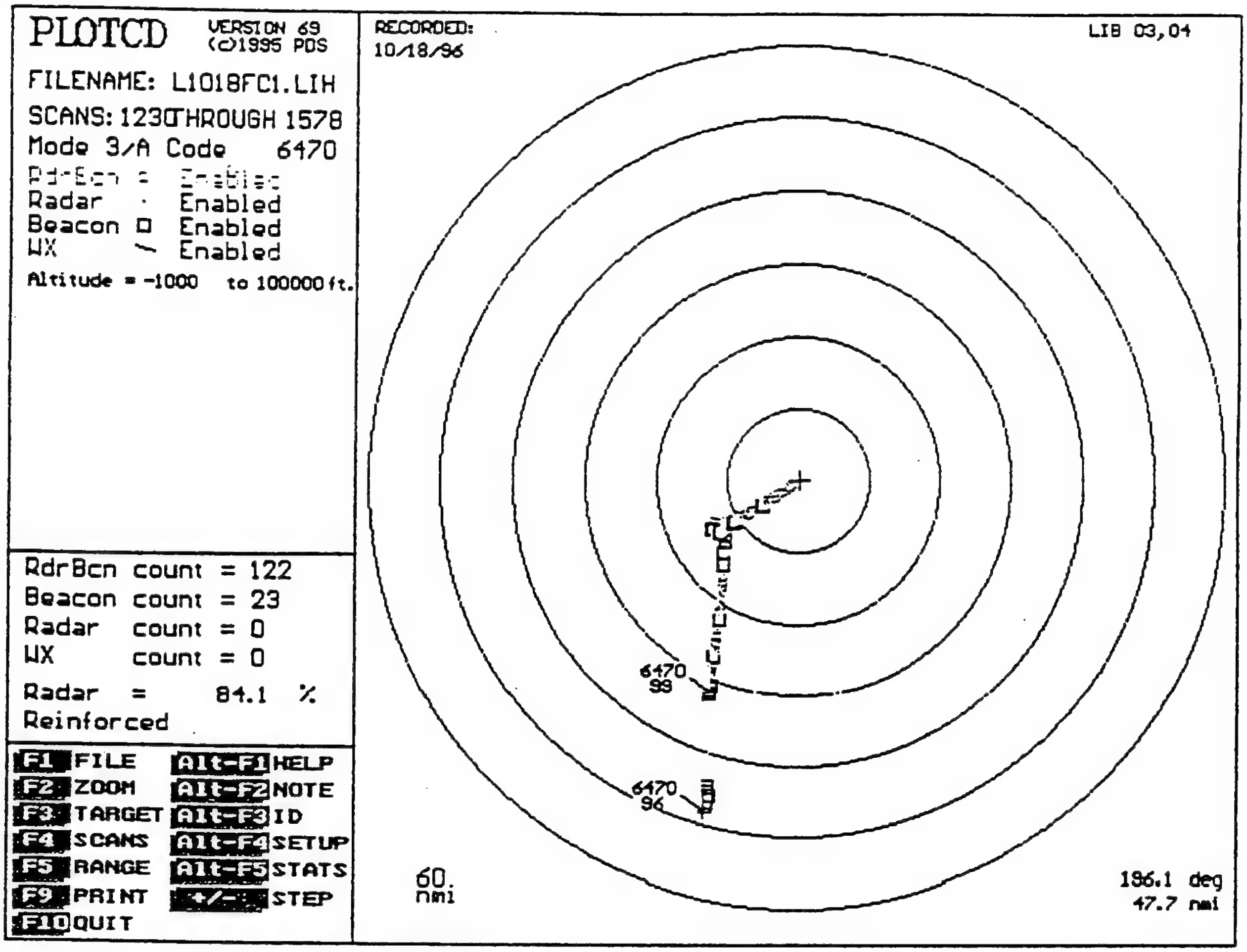


Figure 12
CD-1B

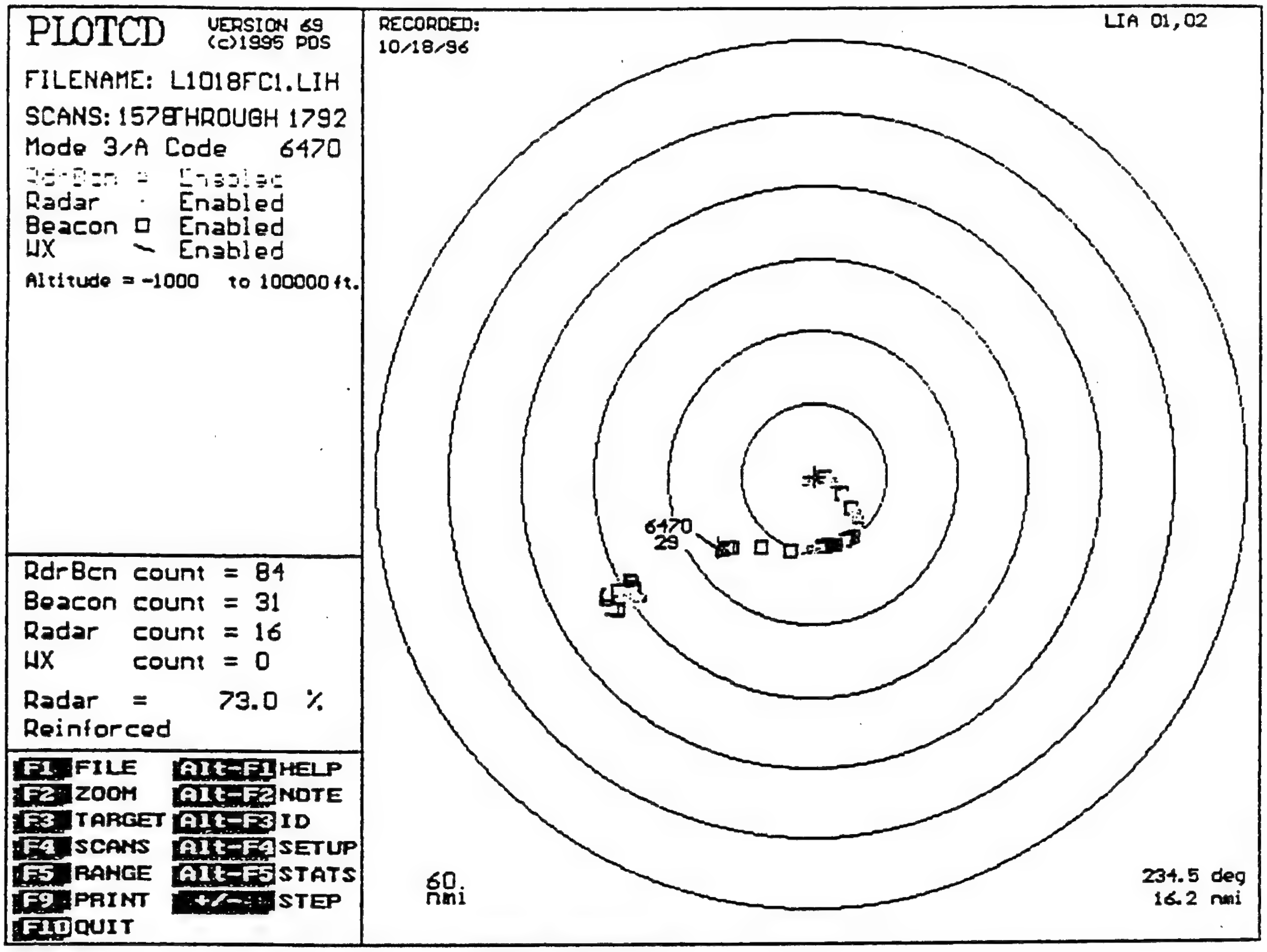


Figure 13
CD-1A

Reference figures 13 and 14. This segment of the flight was flown from the radar site, south of the island and an approach to Barking Sands Airfield. There was no coverage at the Barking Sands Airfield due to severe screening of this area. Coverage to the south of the island was also spotty due to screening.

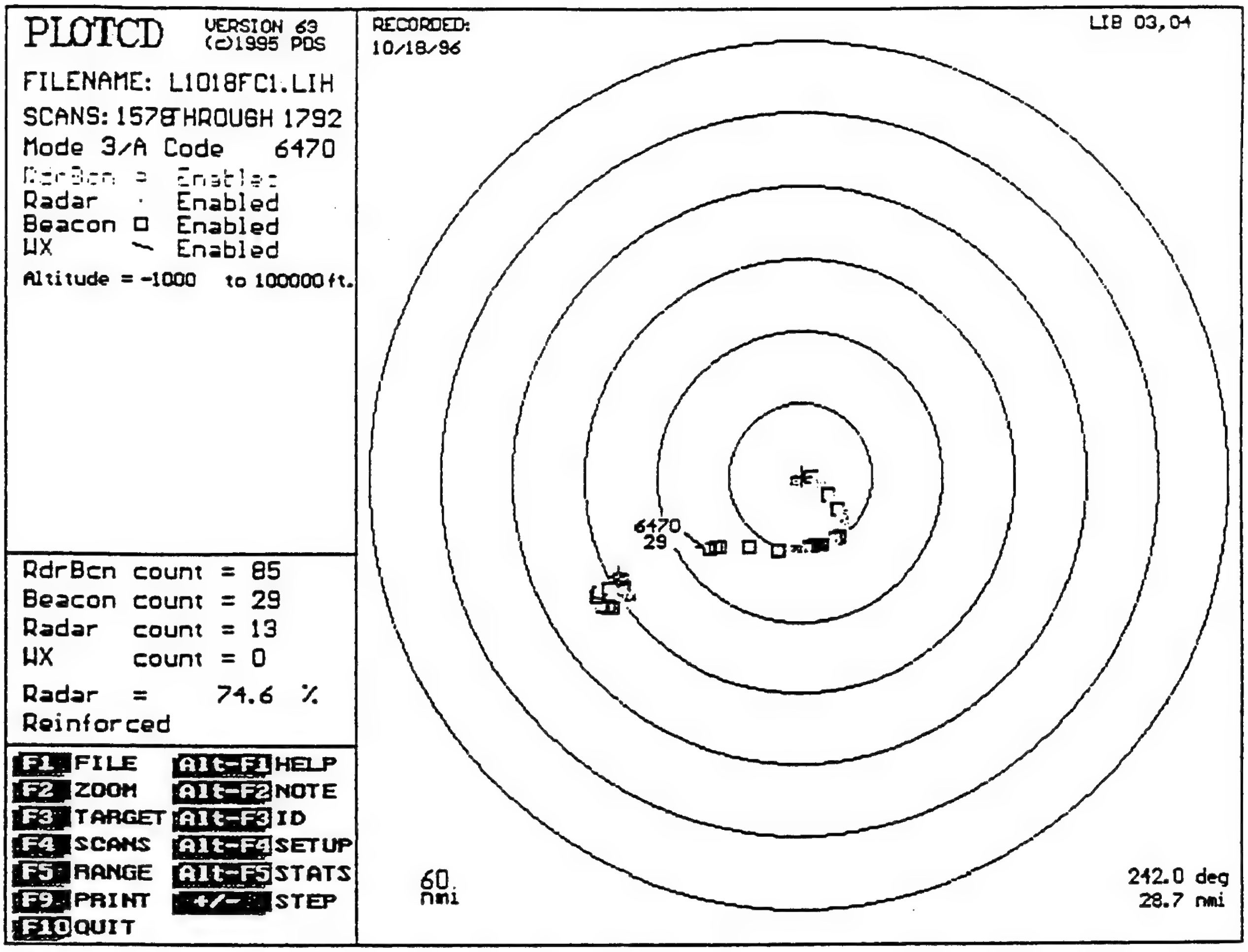


Figure 14
CD-1B

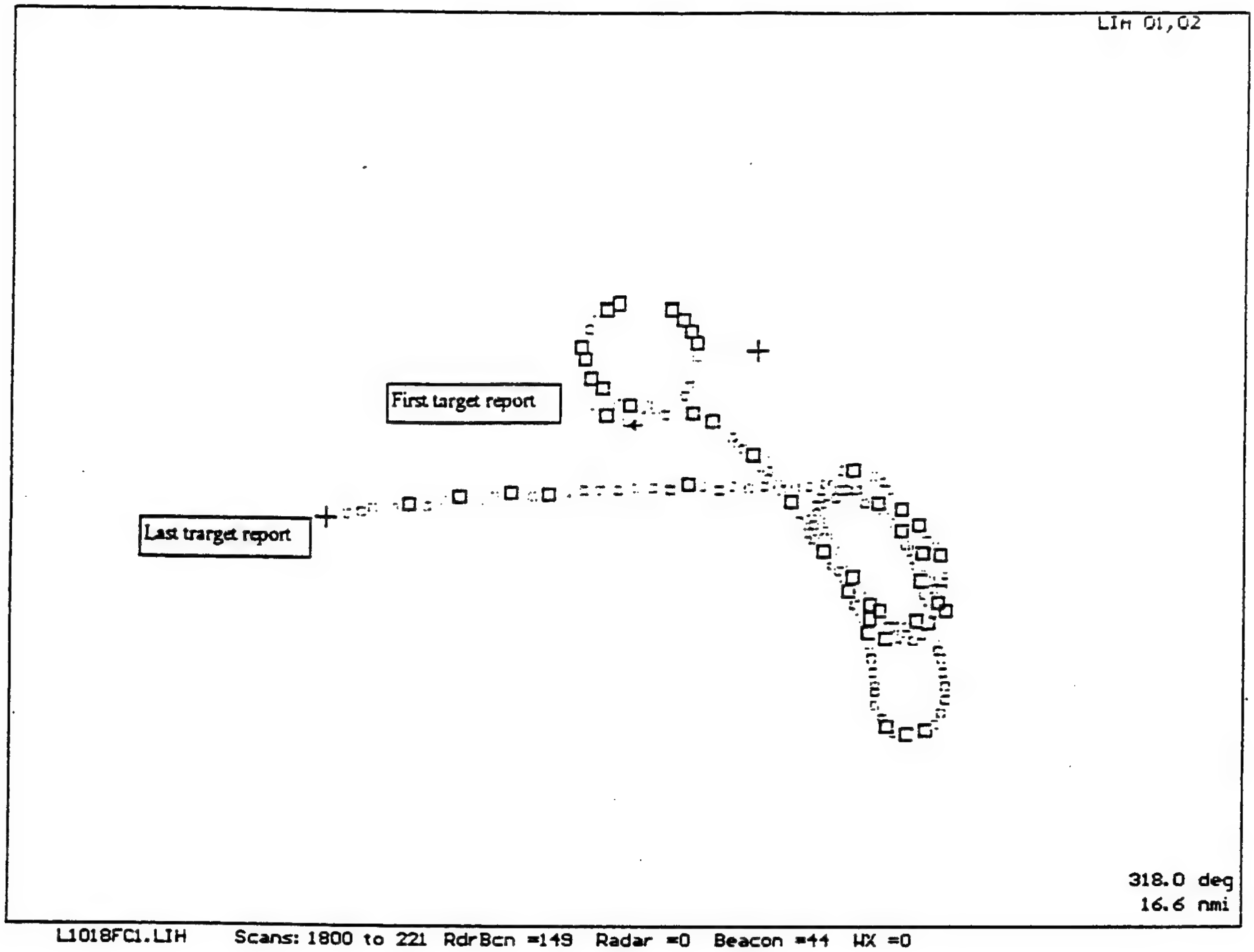


Figure 15
CD-1A

Reference figures 15 and 16. This segment of the flight was flown over and around the Princeville Airport, the Kilauea Lighthouse and a race track north of the Moloaa Forest reserve. The flight check aircraft was flying between 1600 and 2100 Ft during this portion of the flight Coverage was very good in this area at these altitudes. The flight check aircraft had performed a touch and go at Barking Sands prior to this segment (figures 13 and 14). There was no coverage at low altitudes over the western or north western portions of the island until the first report on figures 14 and 15. After this segment the flight check landed at Barking Sands.

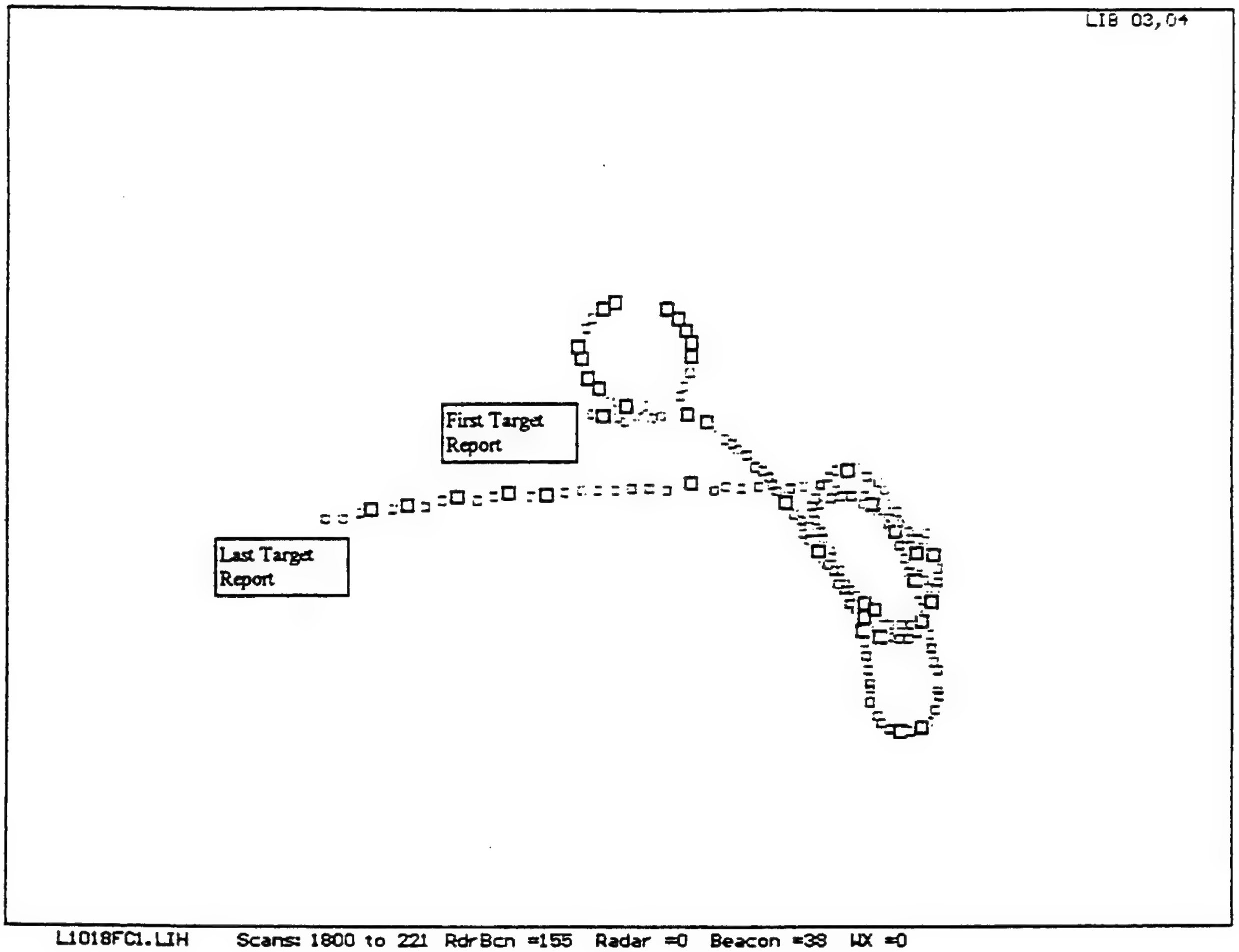


Figure 16
CD-1B

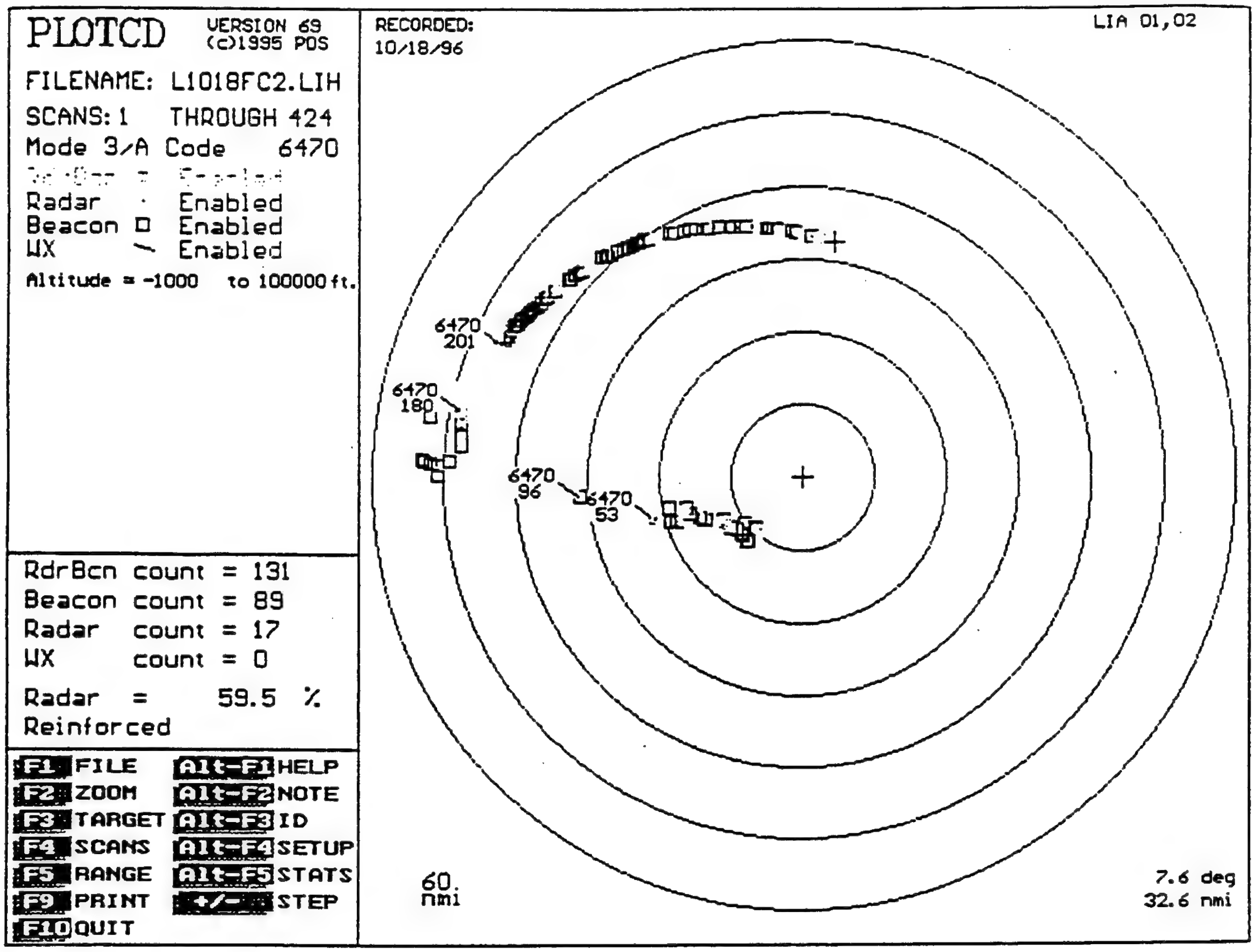


Figure 17
CD-1A

Reference Figures 17 and 18. This is the second flight flown by the flight check aircraft. This flight was flown on the afternoon of 18 Oct. 1996. This portion of the flight was flown to check the coverage over the mountains to the west and northwest of the radar facility. The flight check aircraft departed Barking Sands and proceeded to the SOK VOR at 5000ft. At the SOK VOR the flight check turned around and proceeded on a westerly course. Approximately 20NM from the site coverage was lost. The flight check aircraft began ascending. There was no coverage until the flight check aircraft reached an altitude of 18,000ft and 50NM range. The flight check began a clockwise circle from 270 degrees to 360 degrees. At approximately 280 degrees coverage was lost and the flight check aircraft climbed to 20,200ft and coverage was restored. The flight check continued at this flight level until the flight was terminated when the flight check aircraft reached 360 degrees.

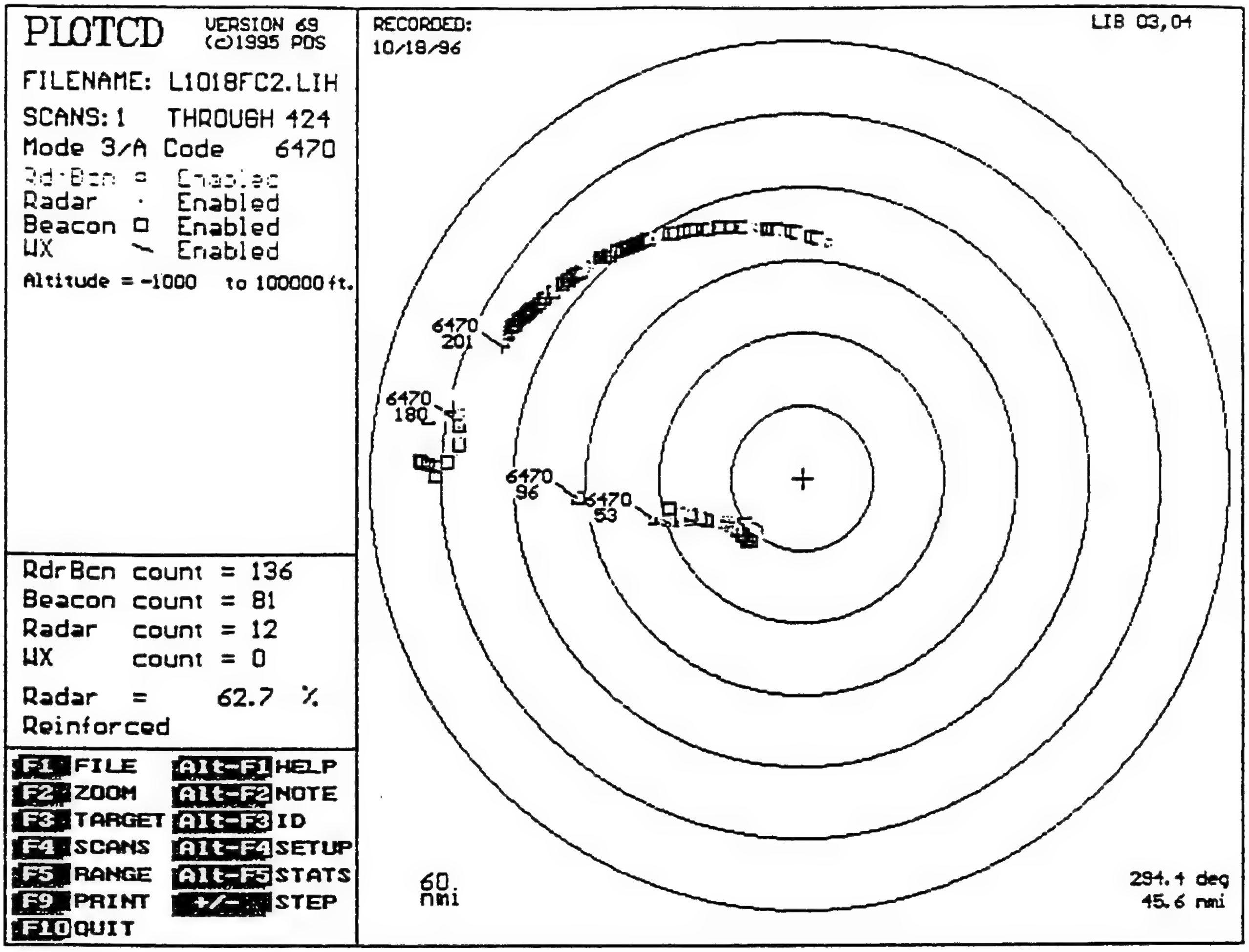


Figure 18
CD-1B

Reference figures 19 through 32 and 43. This portion of the flight check was to determine the outer fringe coverage. The flight check aircraft flew at 7 different altitudes to determine the coverage. The altitudes flow were 1000, 2000, 3000, 5000, 10,000, 20,000, and 35,000 feet. Figures 19 through 32 are plots of each of these altitudes. The data from the flight shows outer fringe coverage for these altitudes.

Figure #s.	Altitude (Ft)	Max Range (NM)
Figure 19 & 20	1000	26 7/8
Figure 21 & 22	2000	40 0/8
Figure 23 & 24	3000	43 1/8
Figure 25 & 26	5000	43 0/8
Figure 27 & 28	10,000	46 2/8
Figure 29 & 30	20,000	59 6/8 (Max range)
Figure 31 & 32	35,000	60 0/8 (Max range)

The data was the same from both CD-1s and the BEXR.

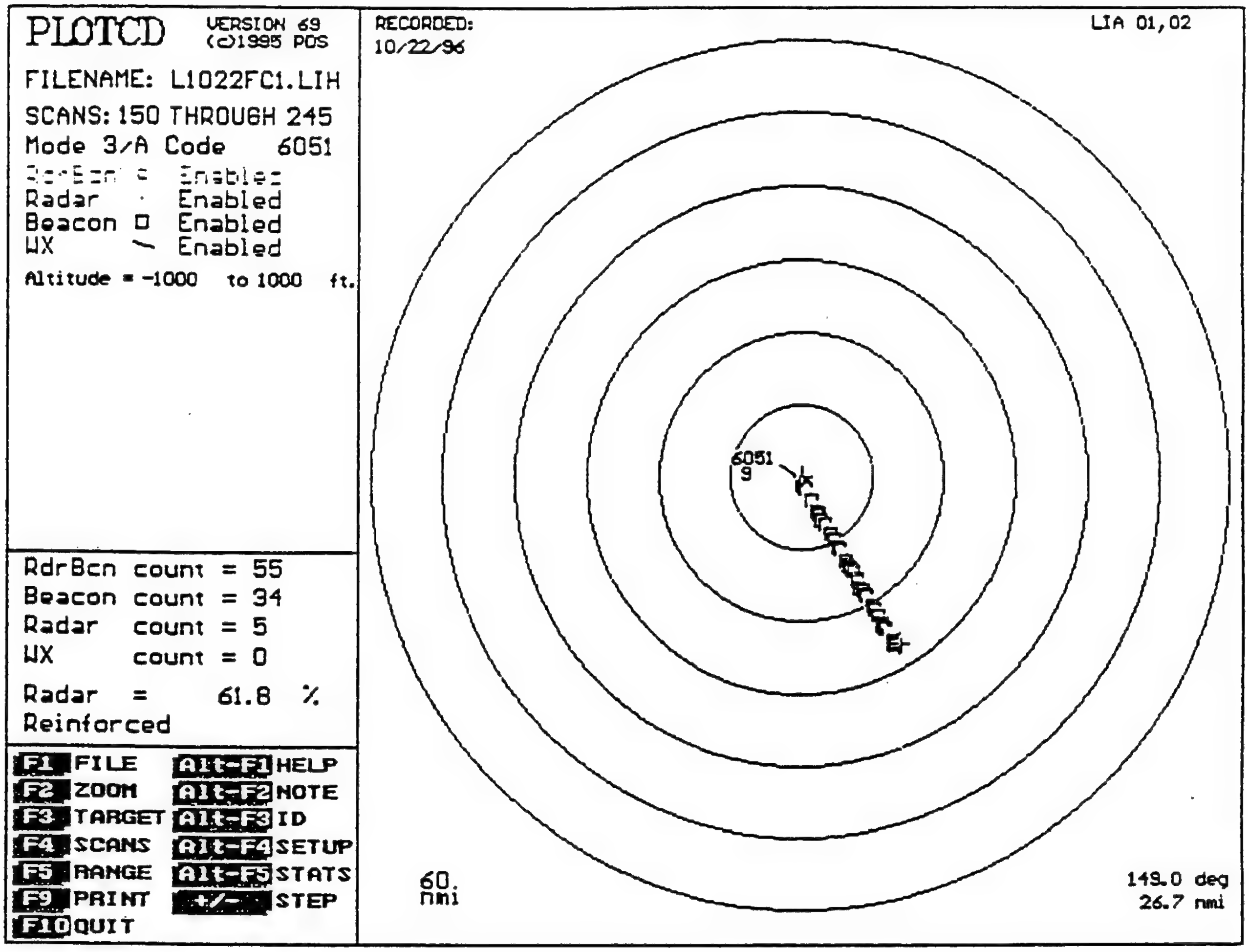


Figure 19
CD-1A

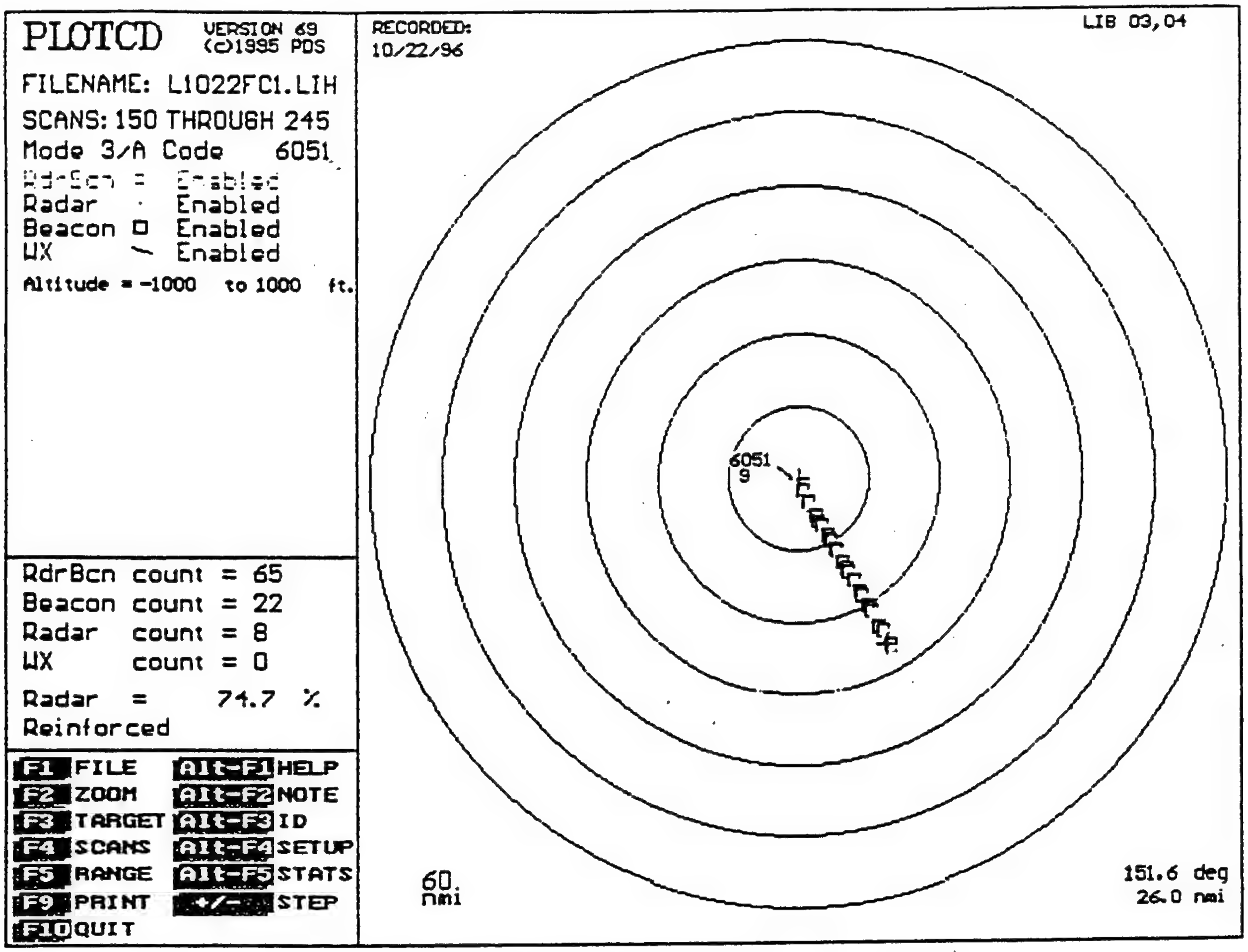


Figure 20
CD-1B

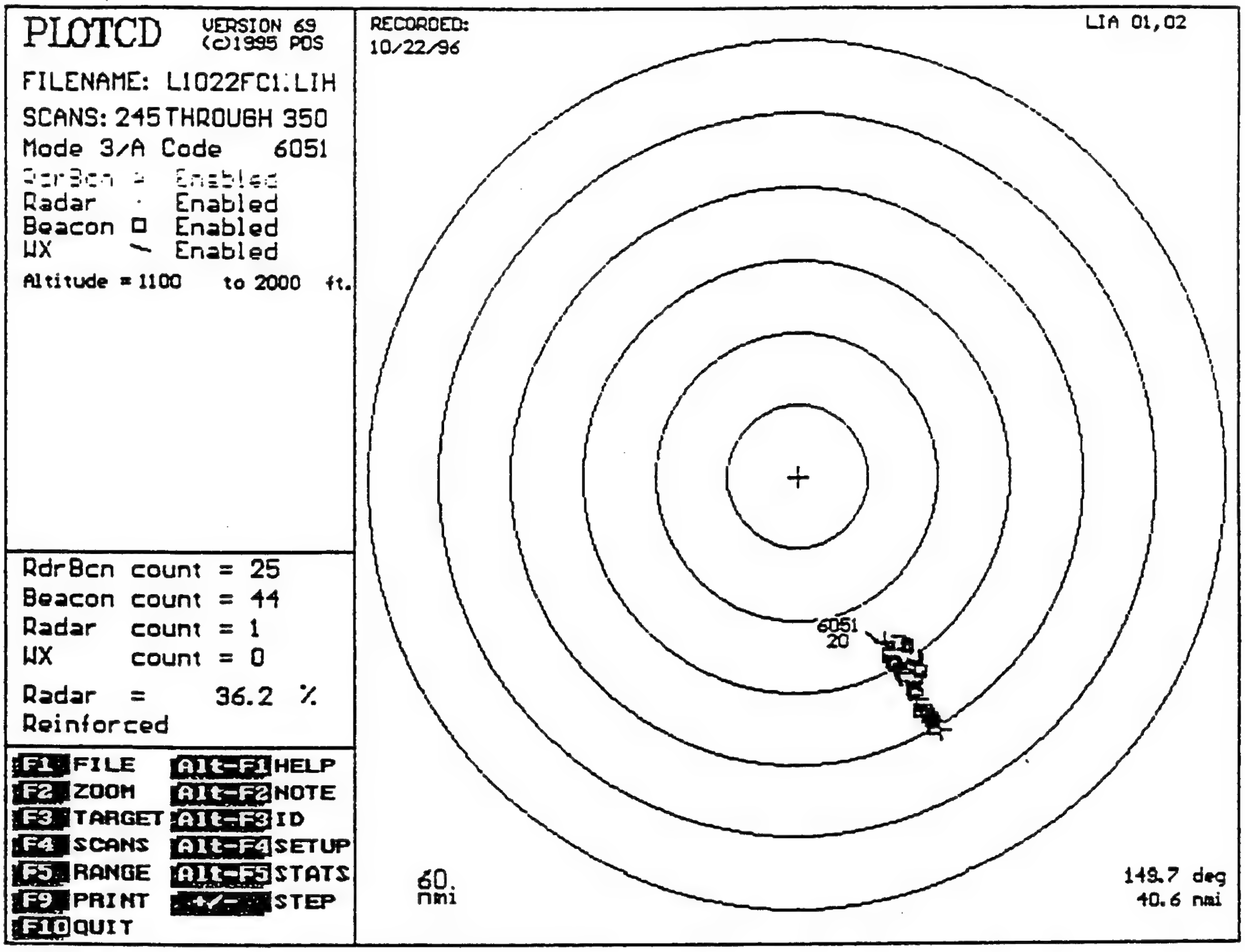


Figure 21
CD-1A

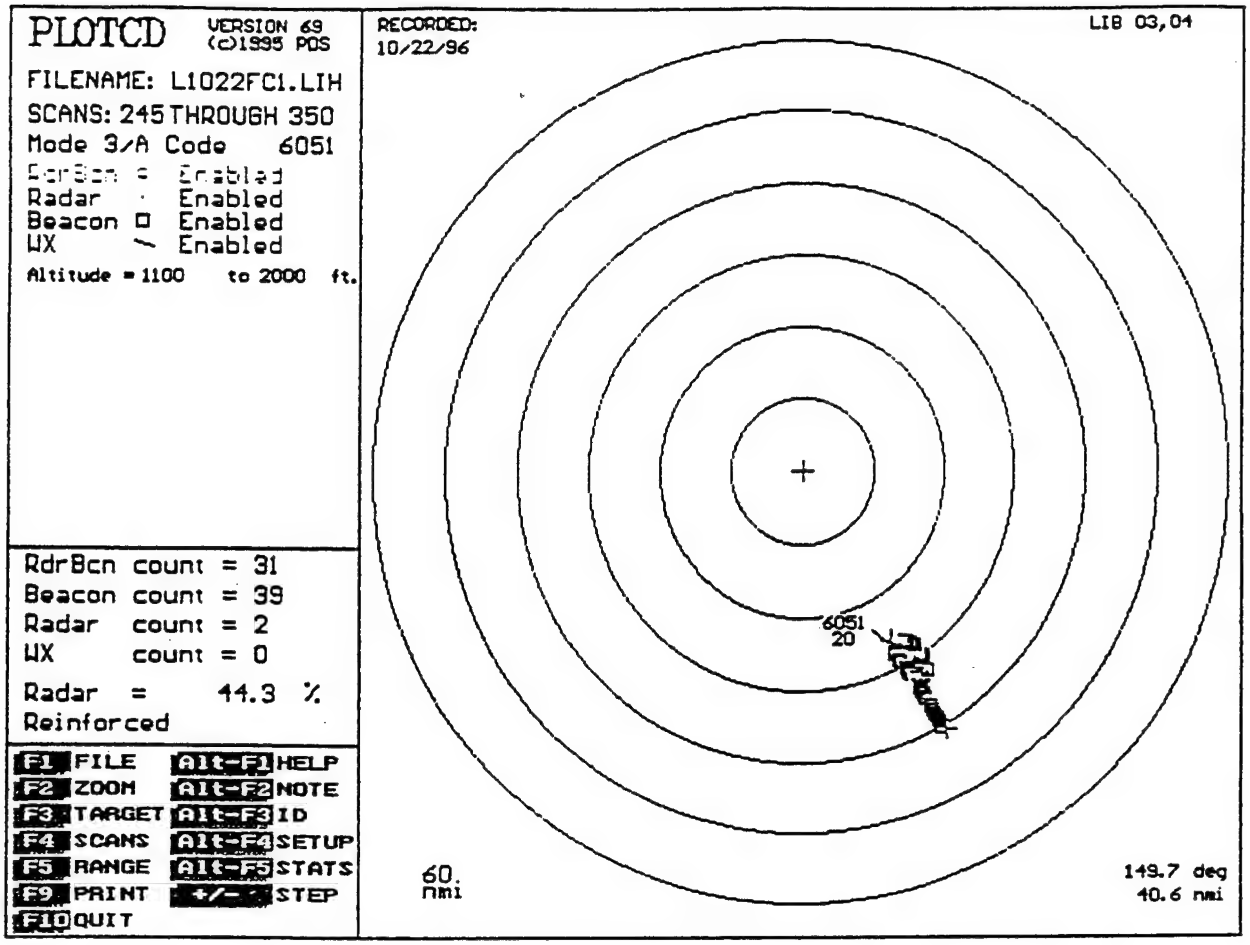


Figure 22
CD-1B

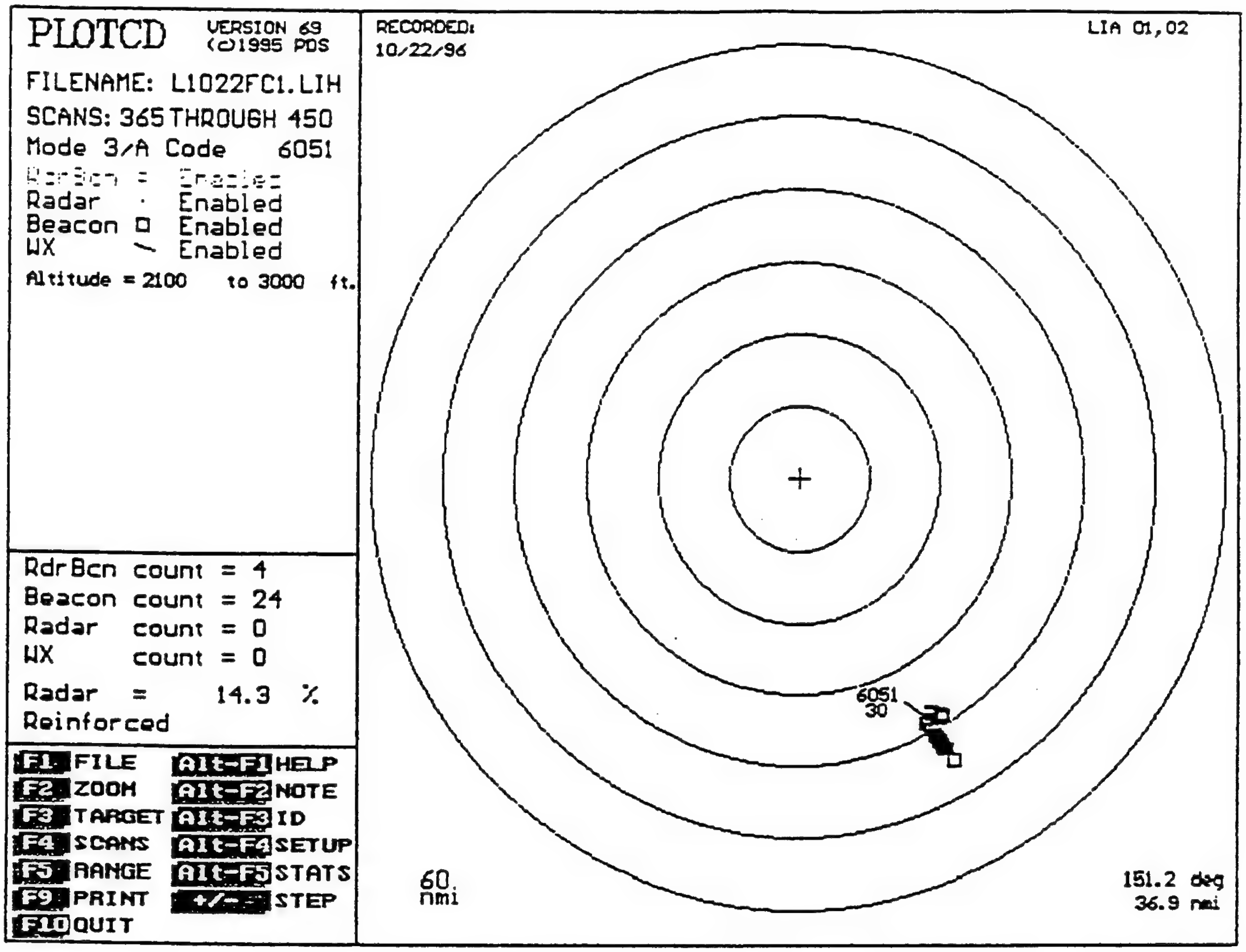


Figure 23
CD-1A

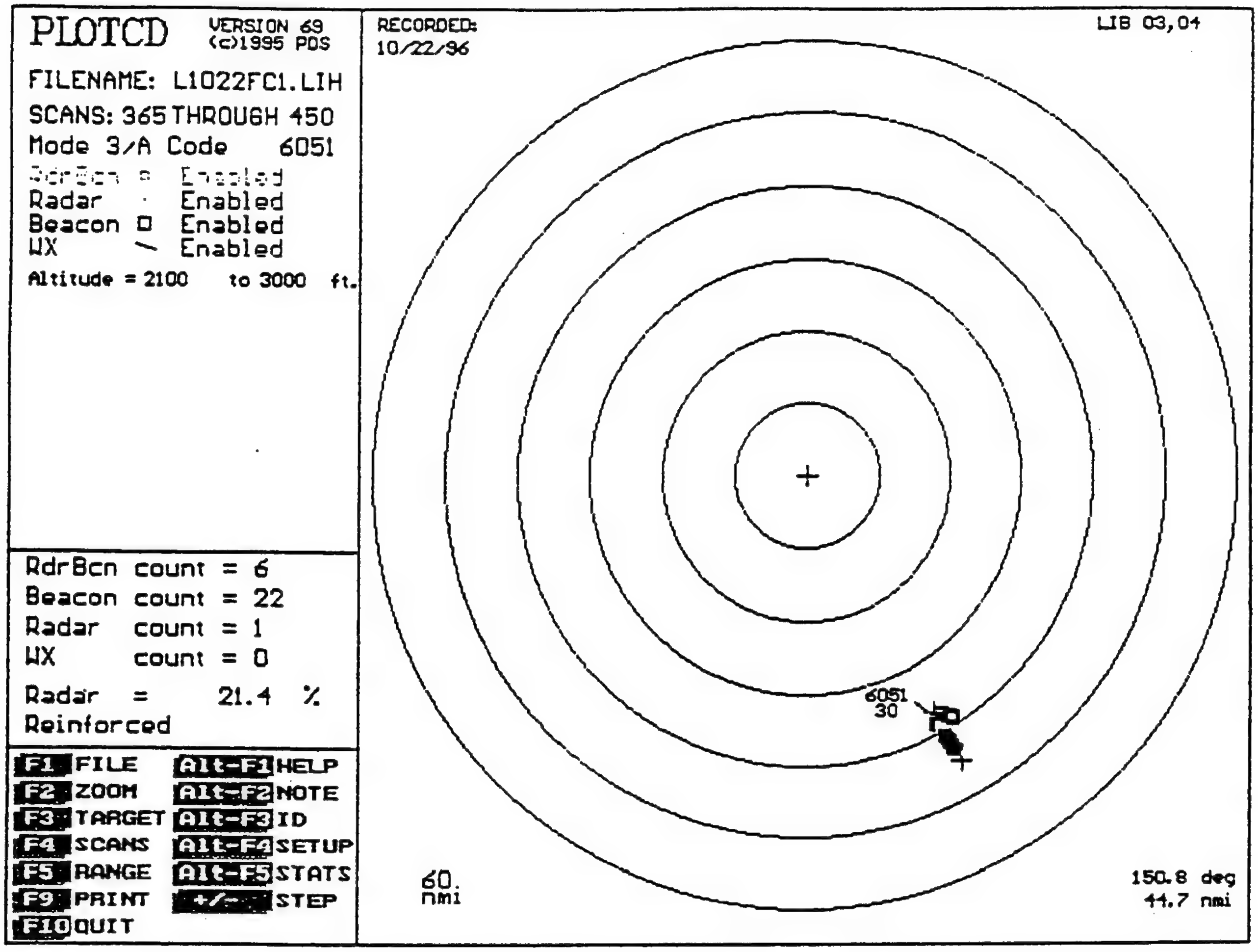


Figure 24
CD-1B

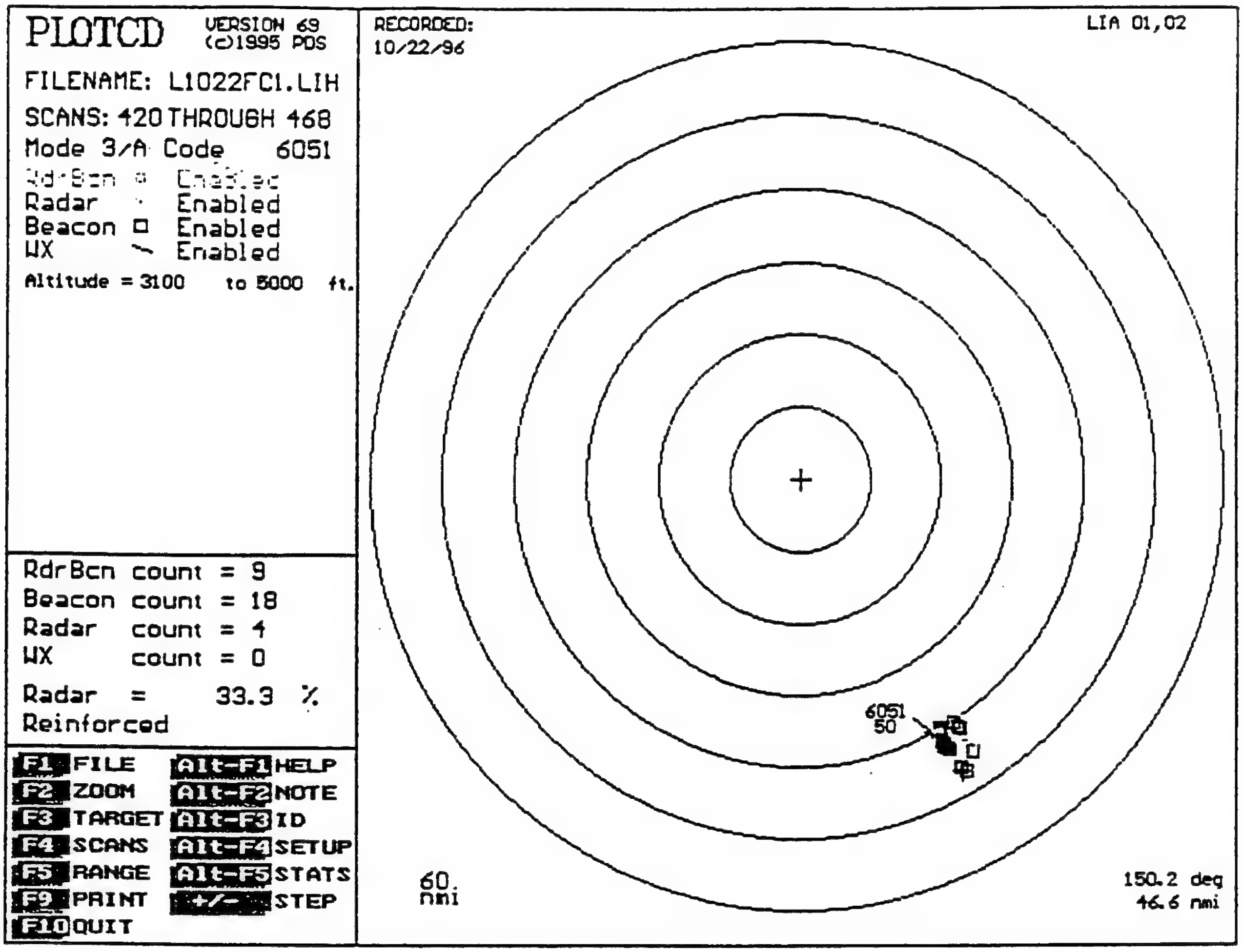


Figure 25
CD-1A

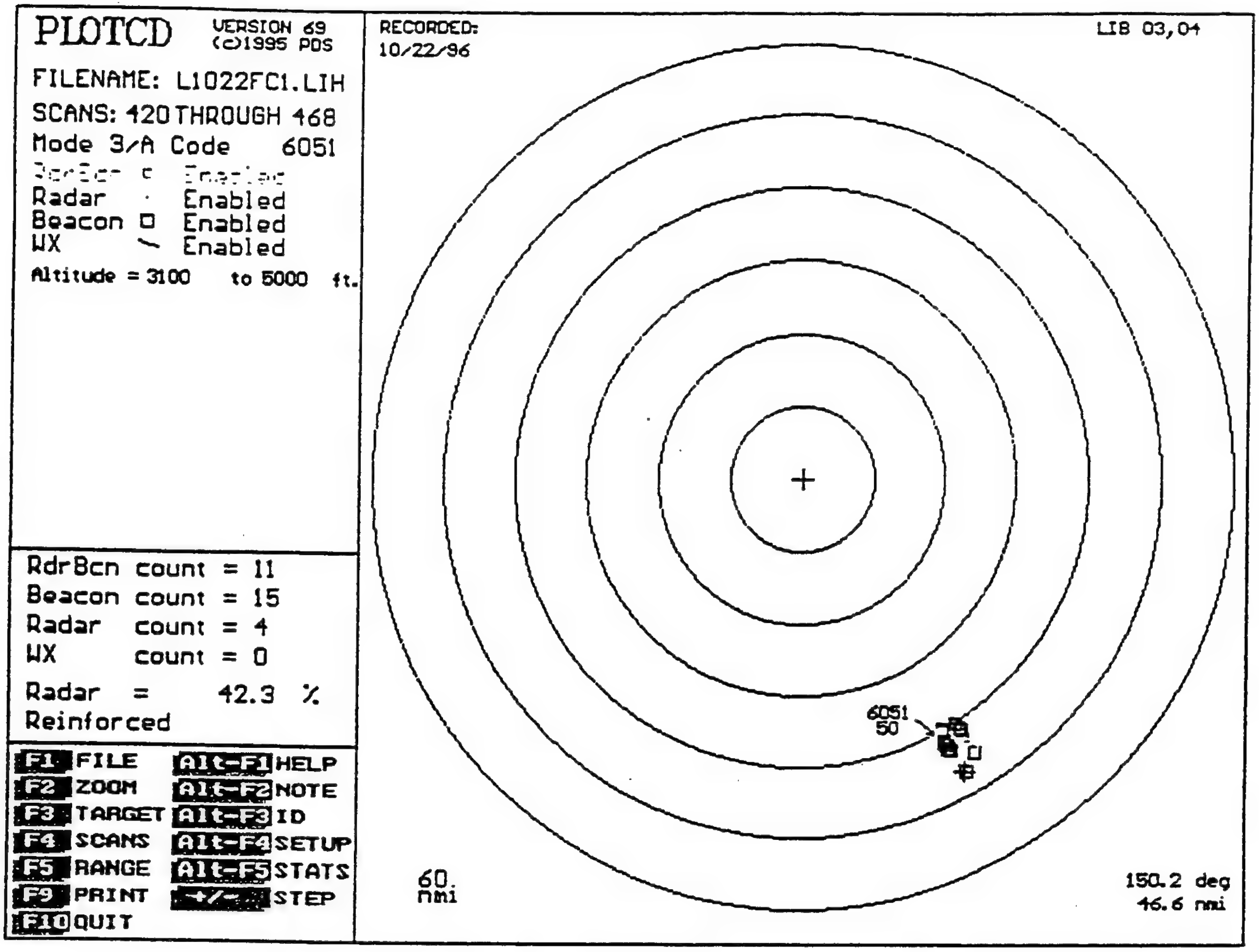


Figure 26
CD-1B

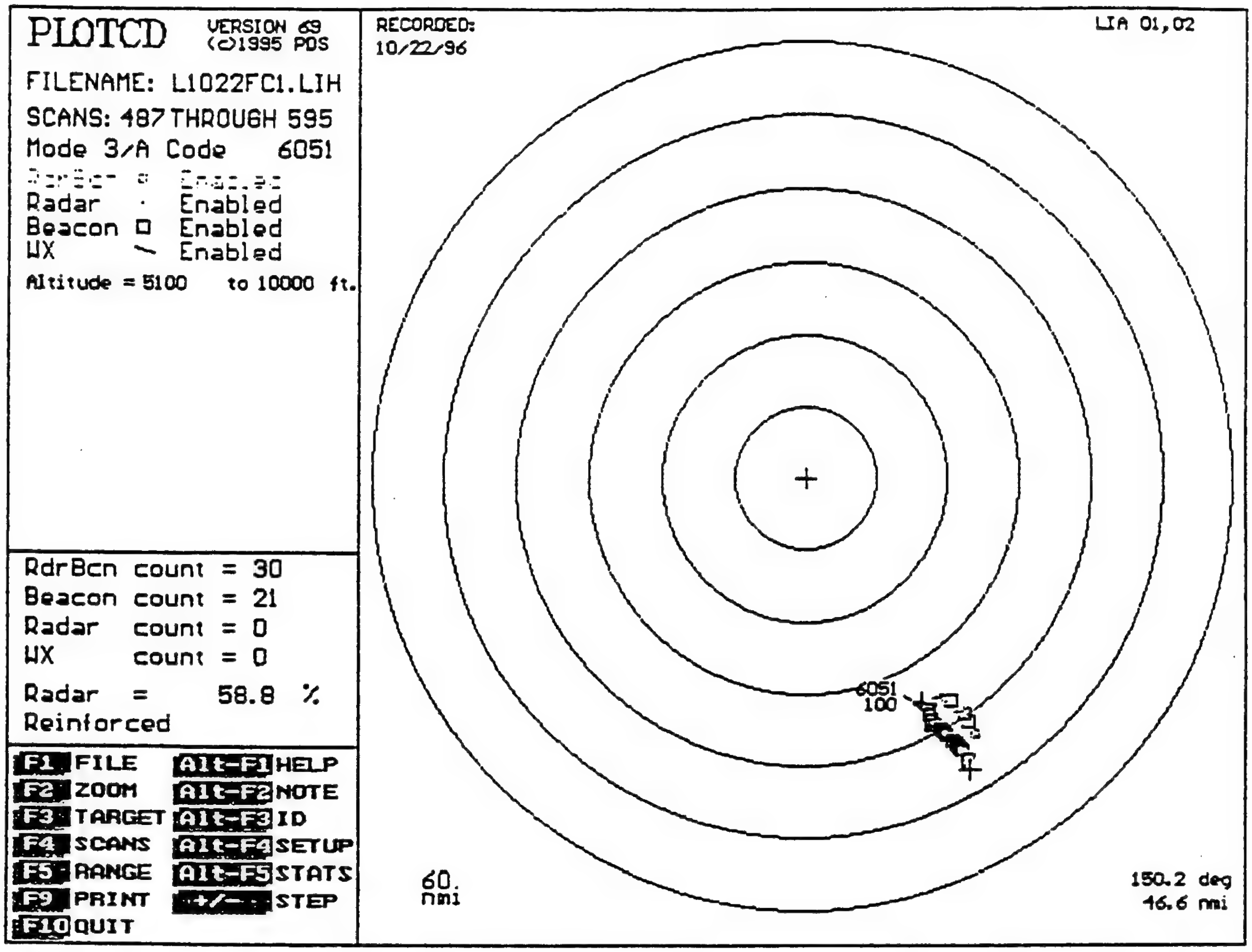


Figure 27
CD-1A

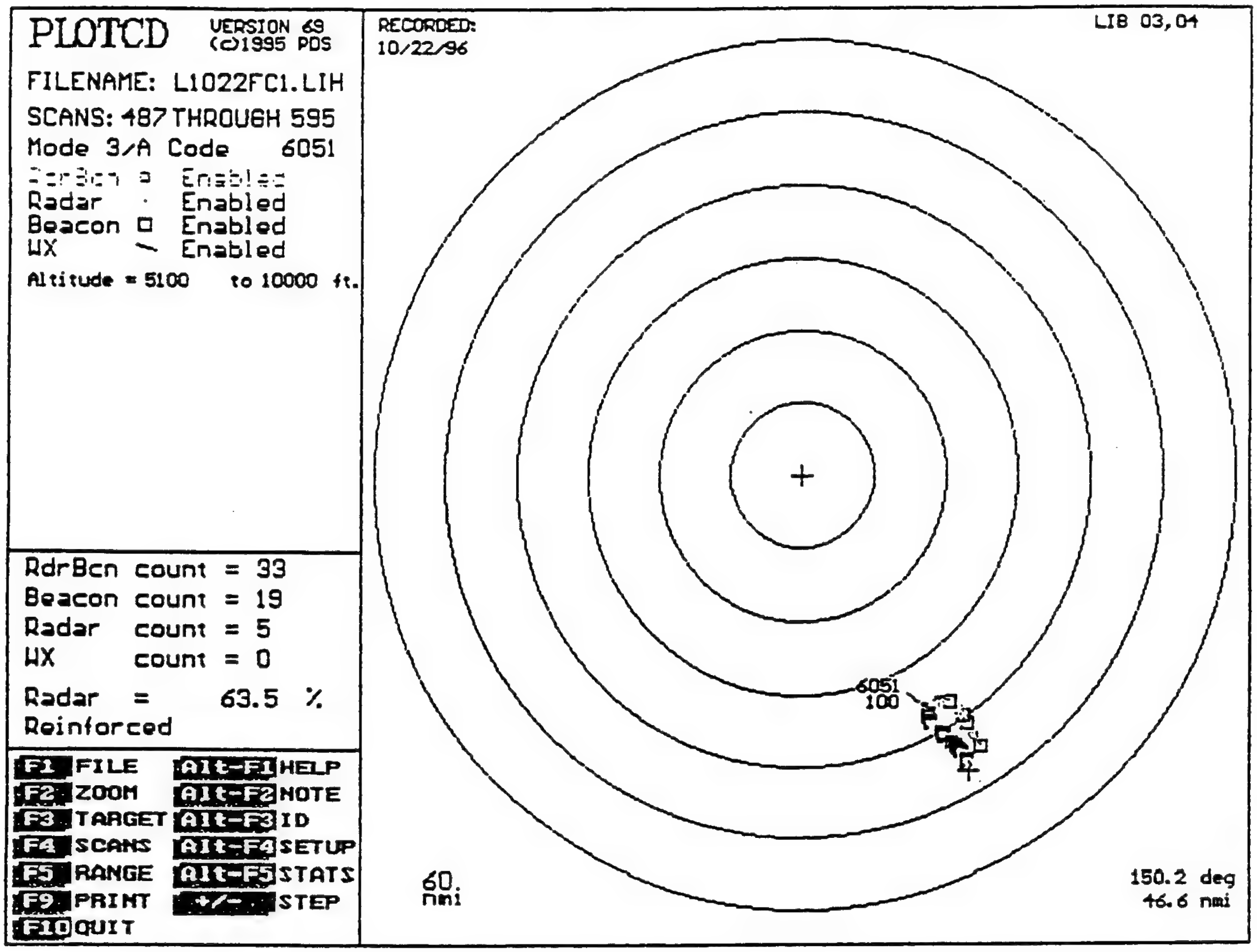


Figure 28
CD-1B

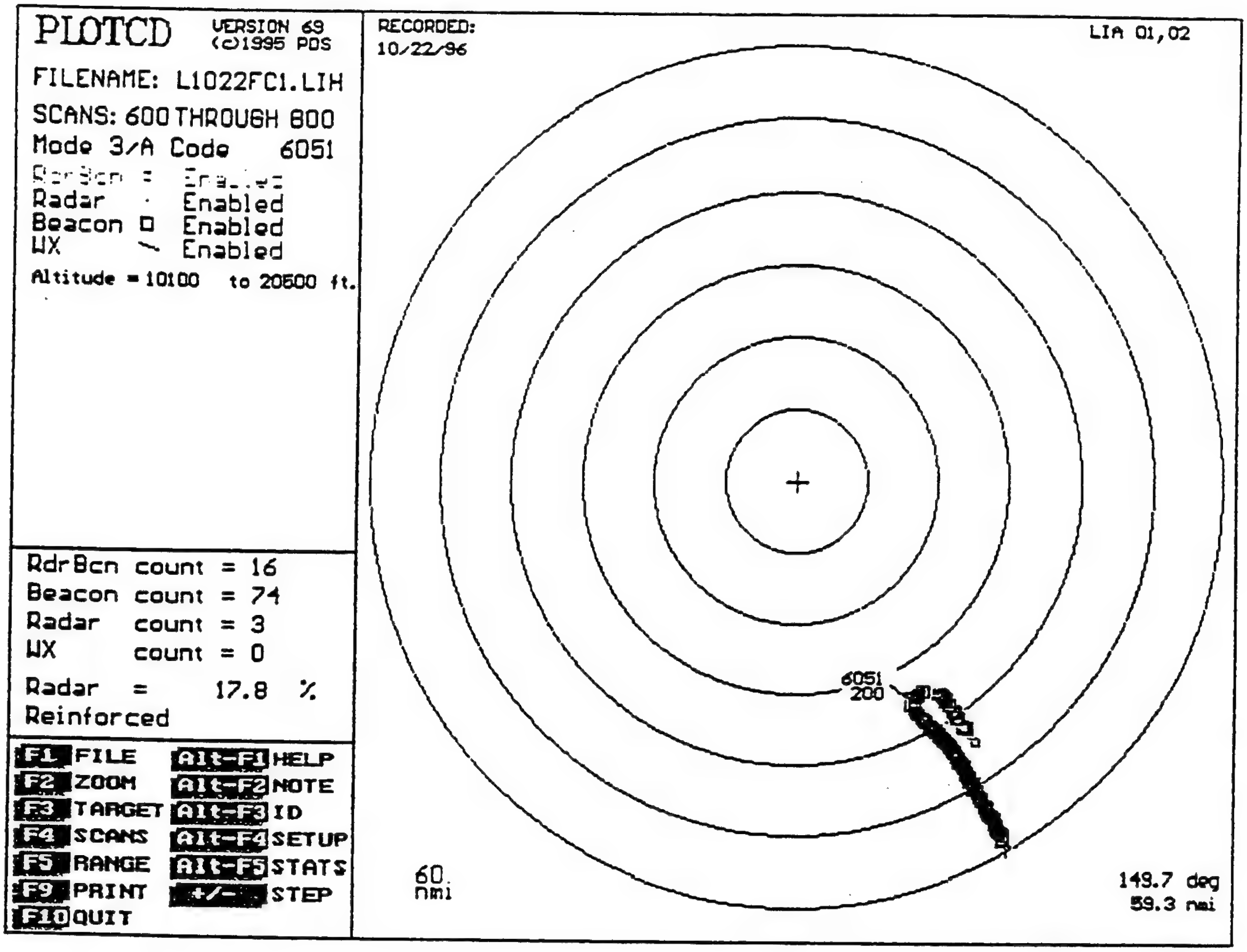


Figure 29
CD-1A

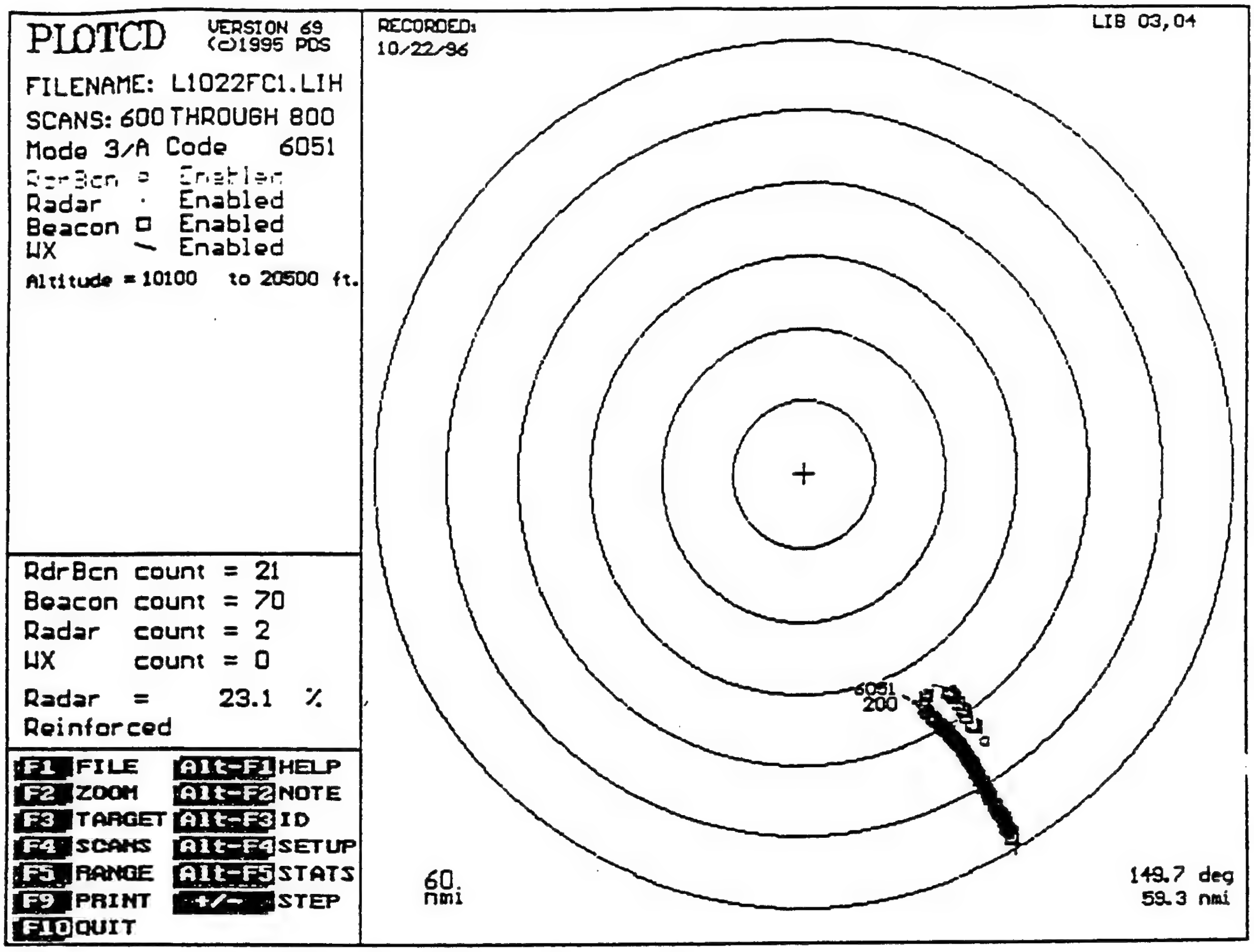


Figure 30
CD-1B

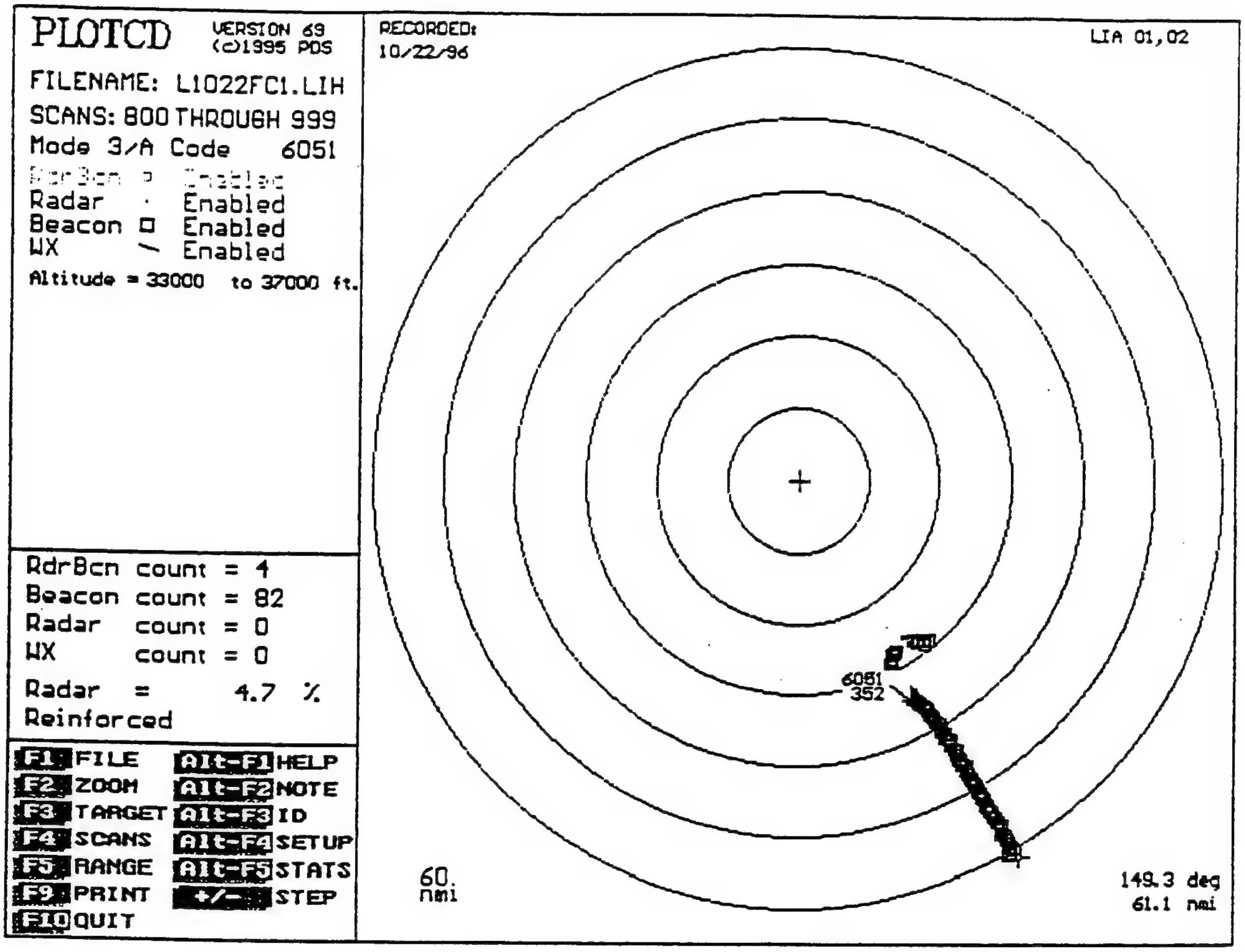


Figure 31
CD-1A

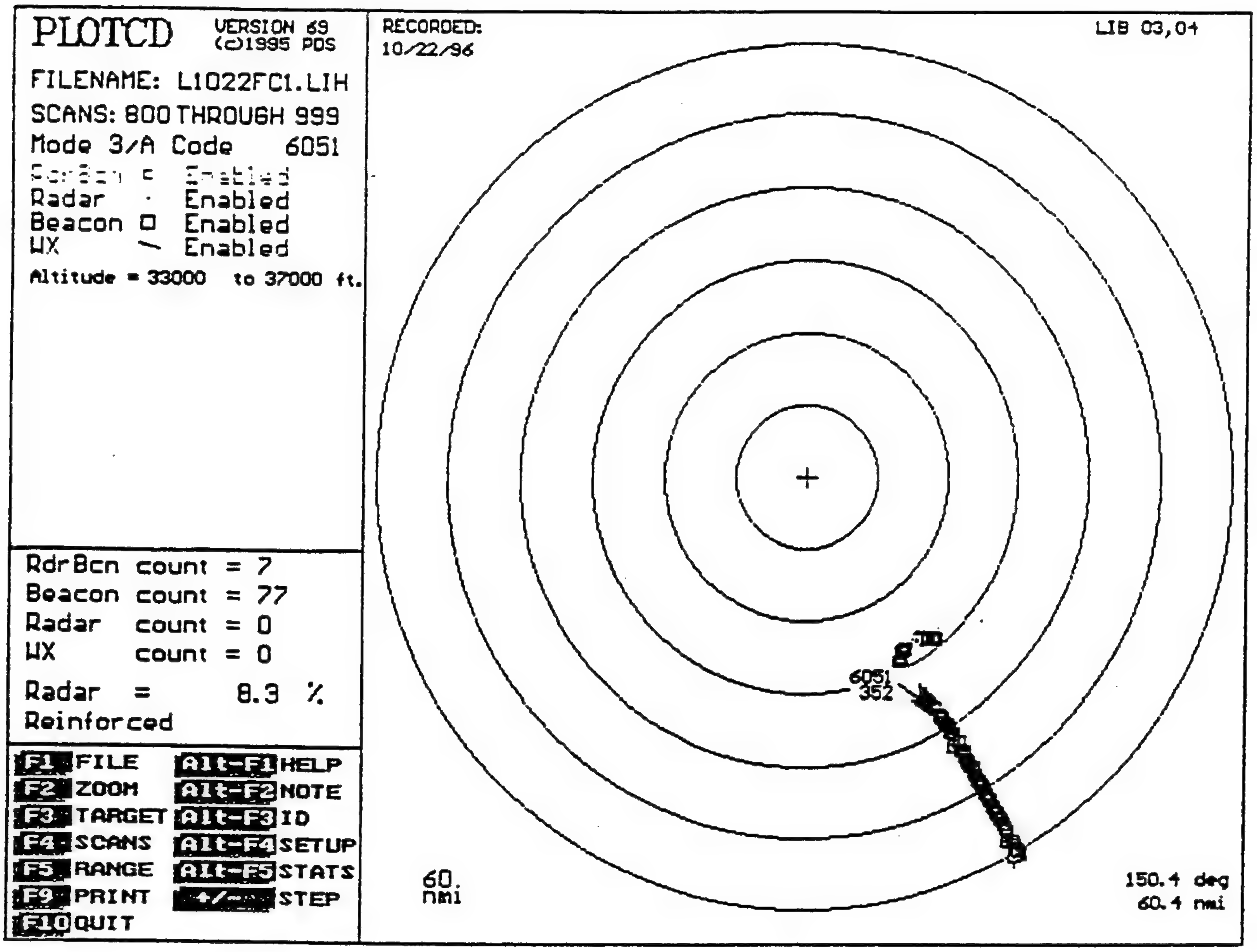


Figure 32
CD-1B

Reference figures 33 through 42 and 43. This protion of the flight was flown to check the inner fringe coverage (cone of silence). The flight check aircraft flew at the following altitudes to test the coverage, 35,000, 20,000, 10,000, 5000 and 3000 feet.

Figure #s.	Altitude (FT)	Min Rng (NM)
Figure 33 & 34	35,000	8 0/8
Figure 35 & 36	20,000	4 7/8
Figure 37 & 38	10,000	2 3/8
Figure 39 & 40	5000	1 4/8(Effective minimum range of radar)
Figure 41 & 42	3000	1 2/8(Effective minimum range of radar)

Figure 43 is the altitude vs range plot of the entire flight from CD-1A the plot from CD-1B was practically identical and is not included.

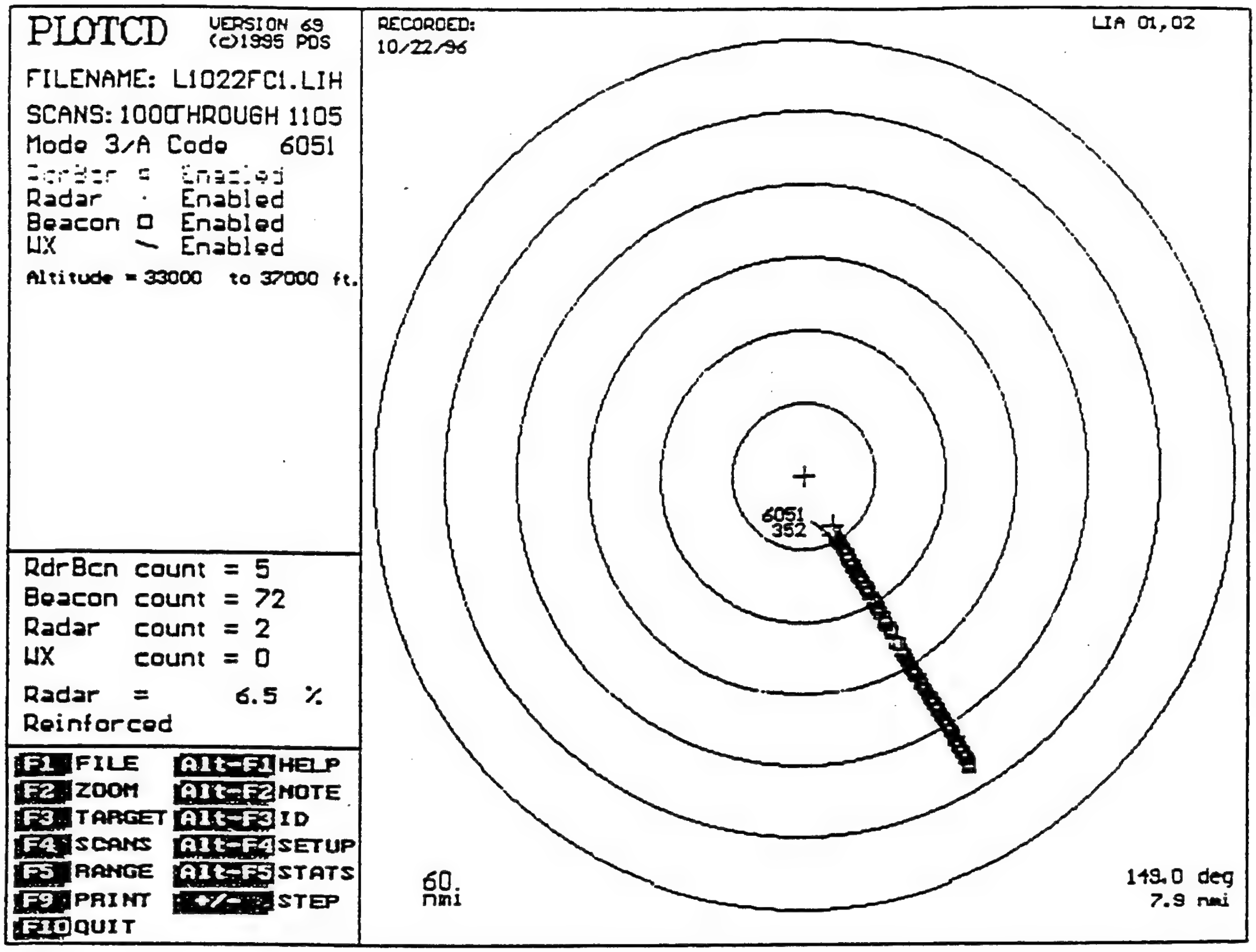


Figure 33
CD-1A

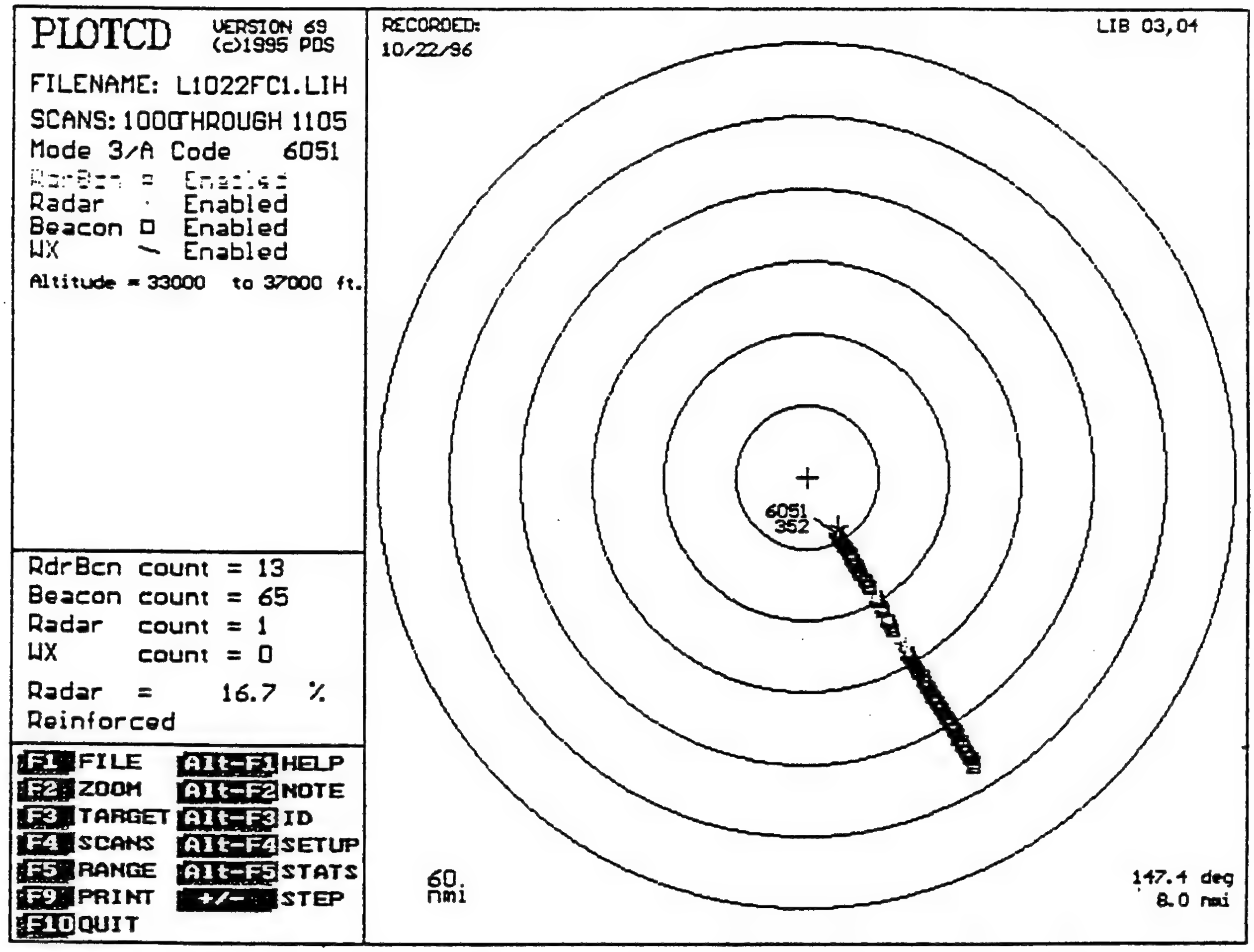


Figure 34
CD-1B

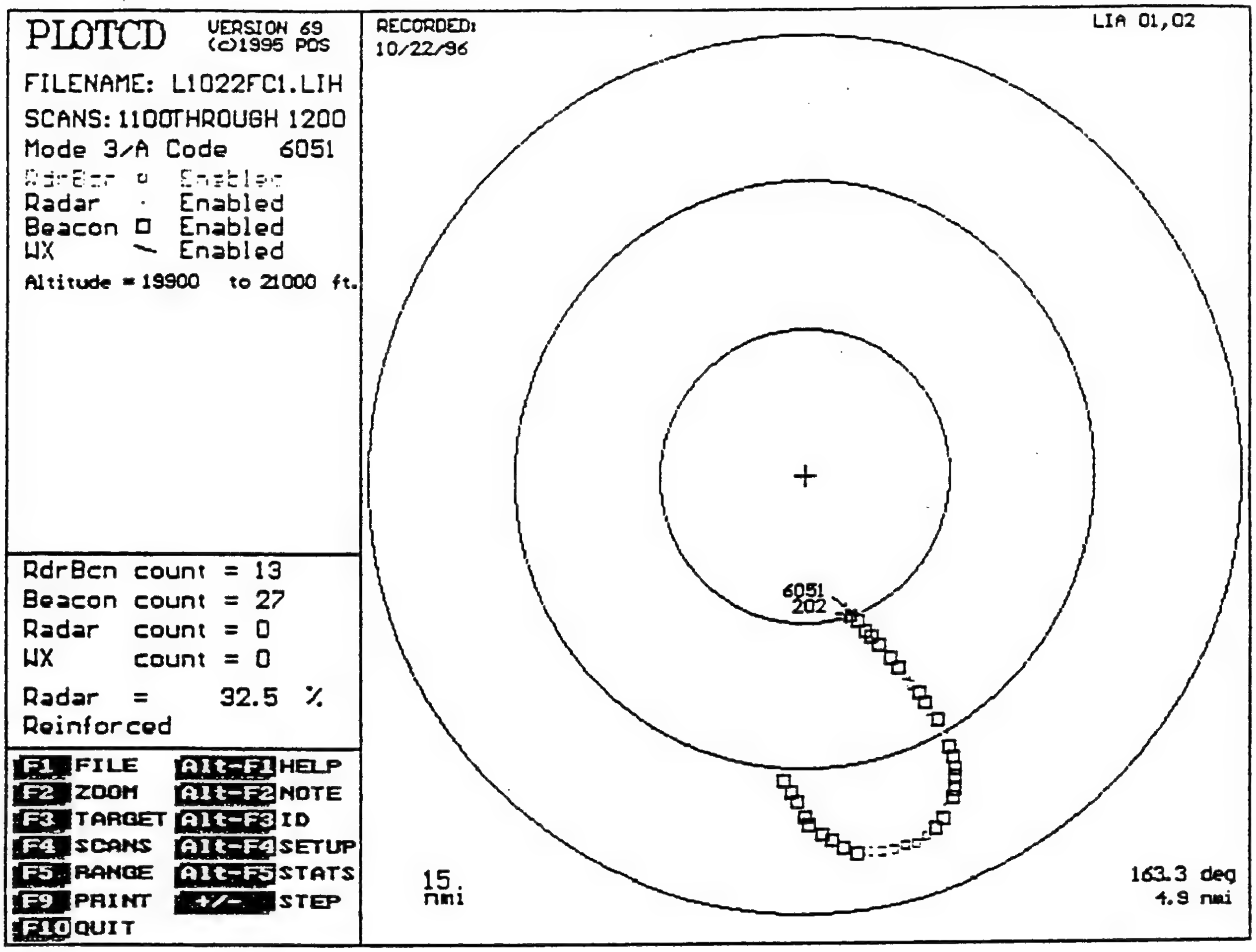


Figure 35
CD-1A

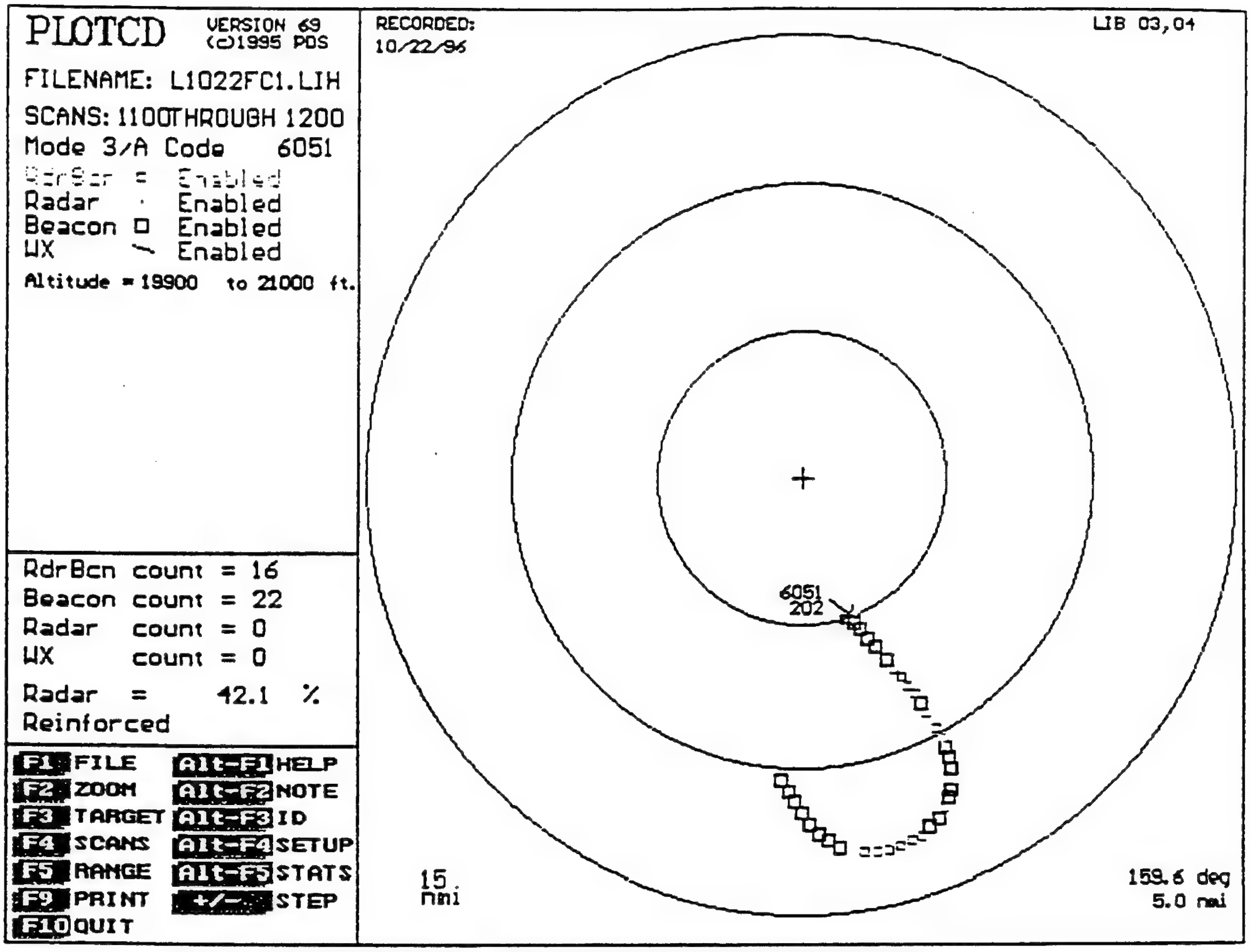


Figure 36
CD-1B

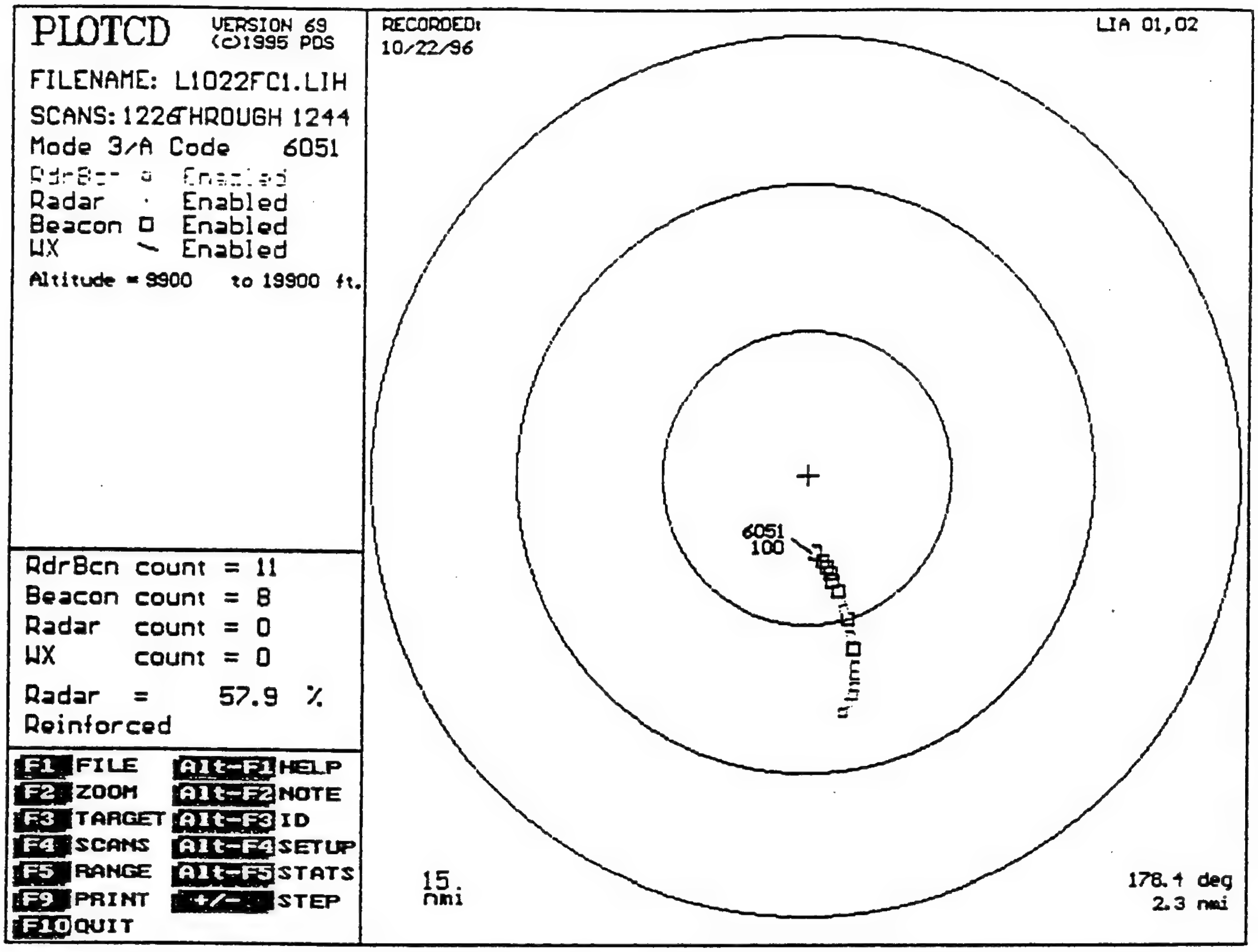


Figure 37
CD-1A

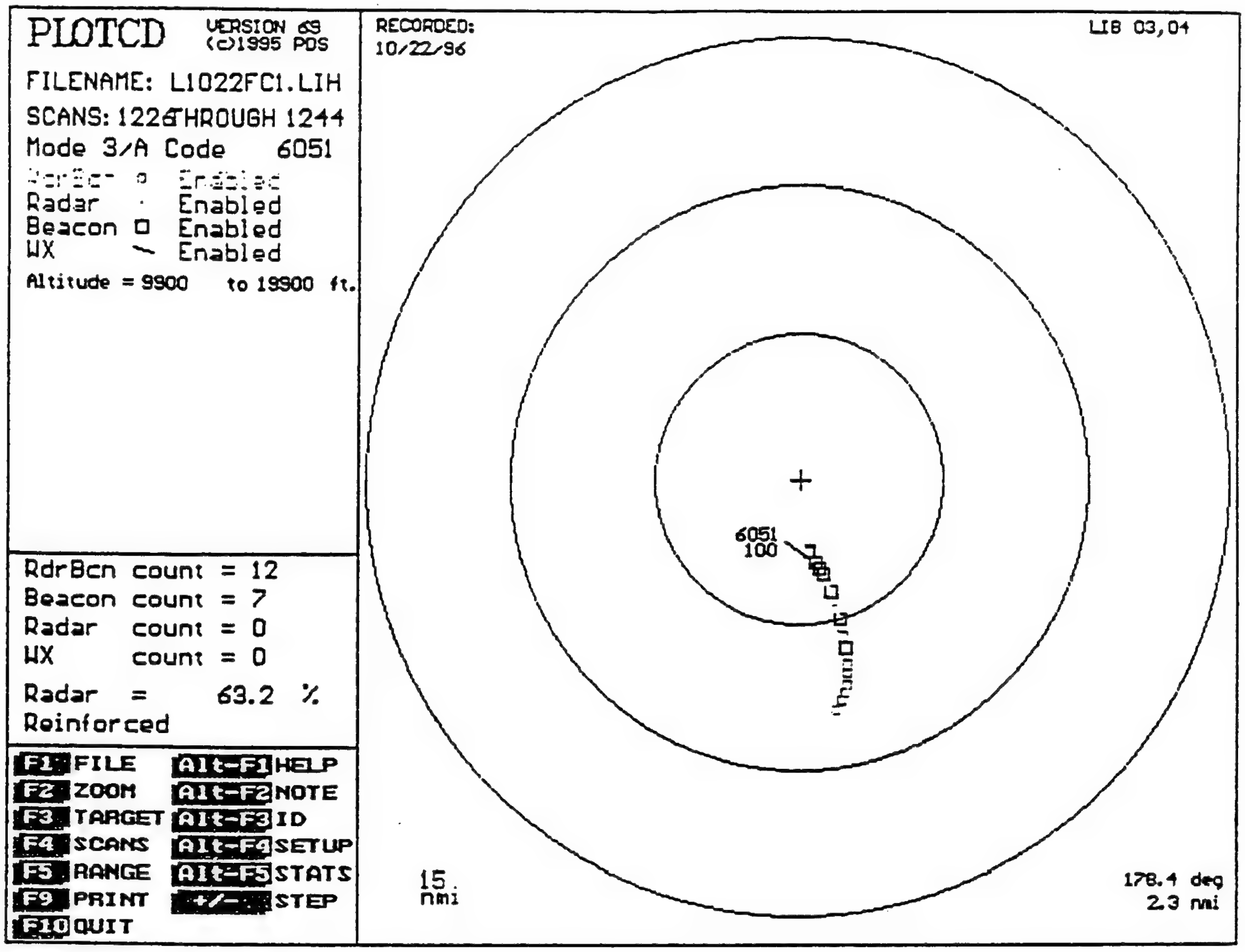


Figure 38
CD-1B

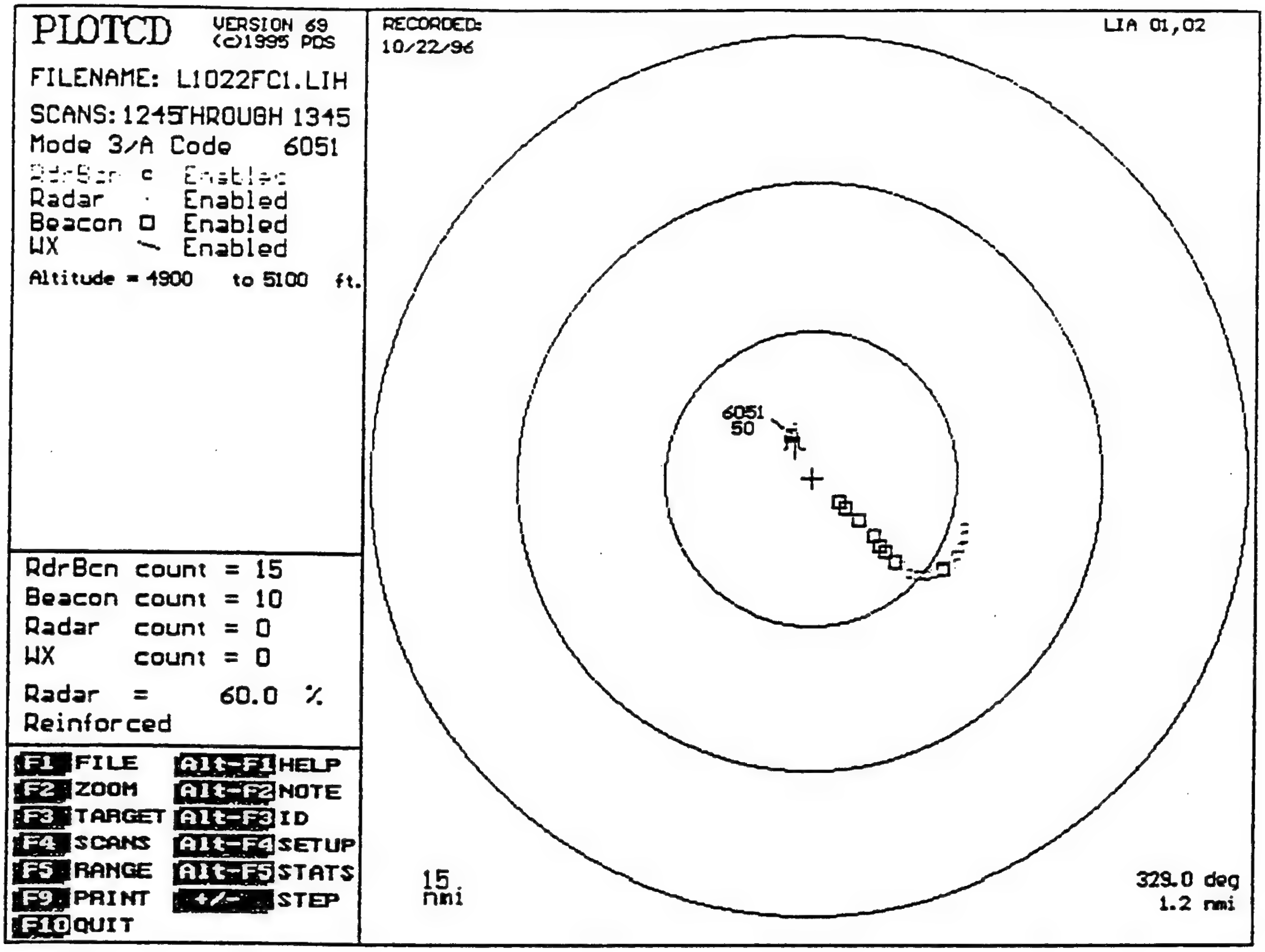


Figure 39
CD-1A

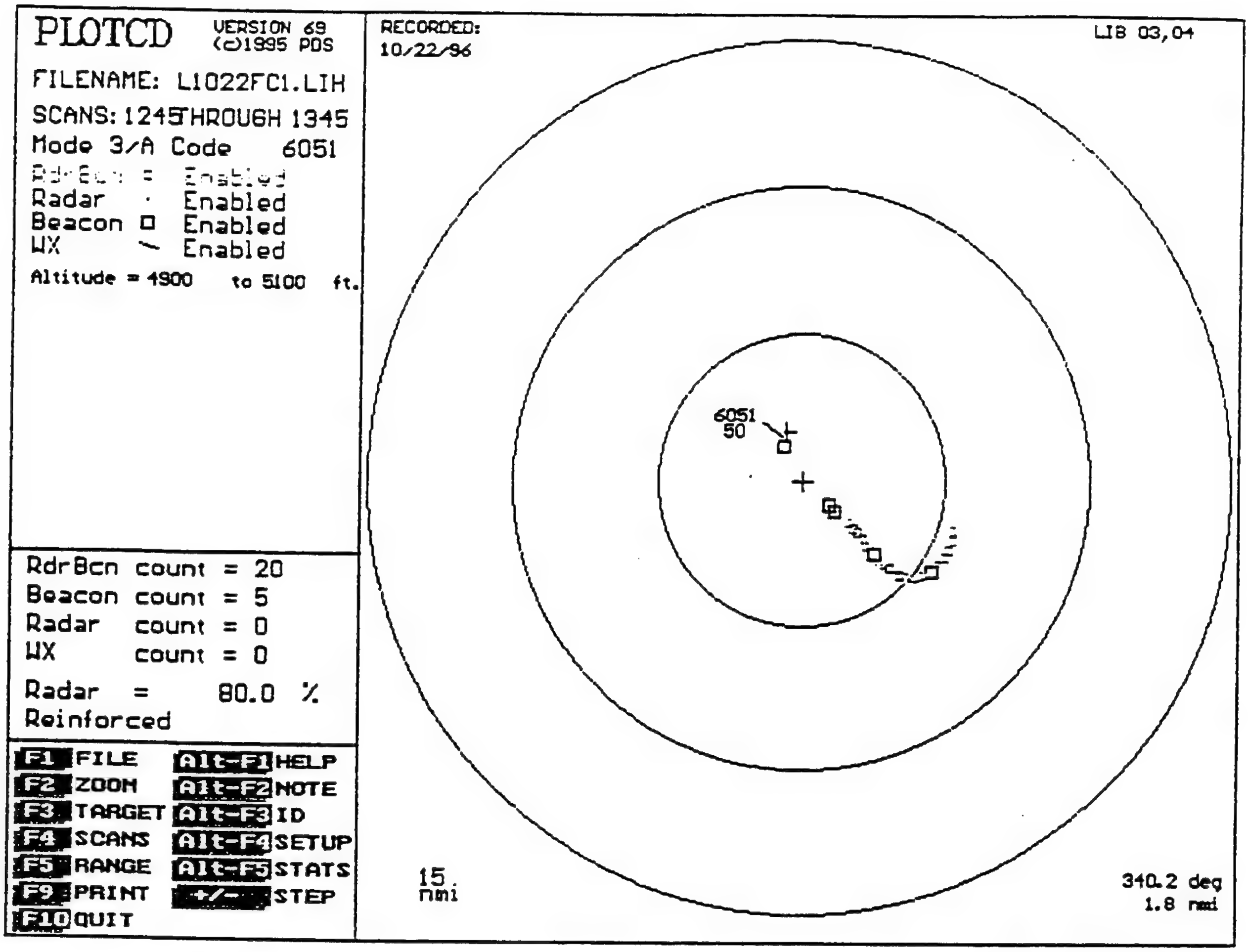


Figure 40
CD-1B

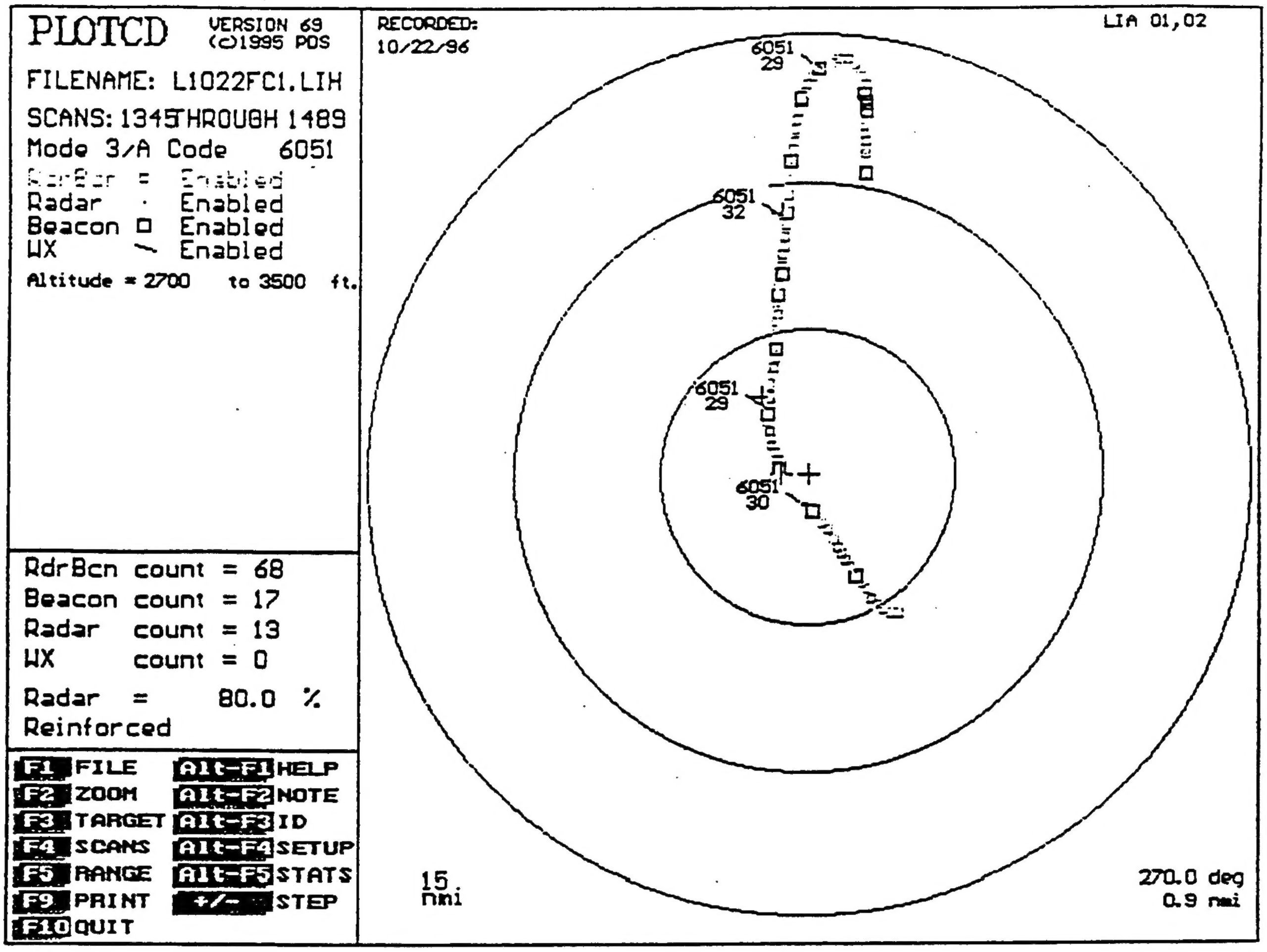


Figure 41
CD-1A

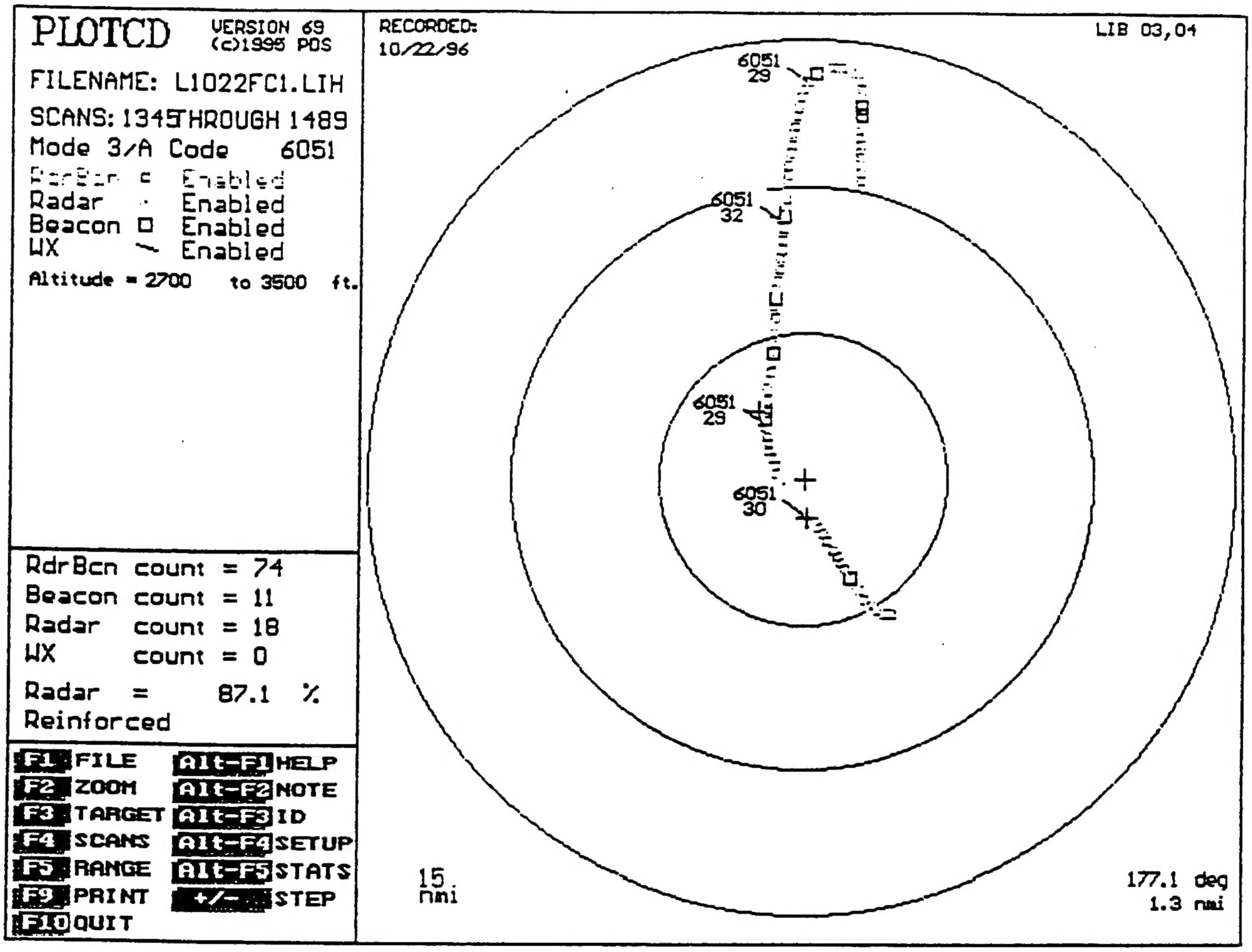


Figure 42
CD-1B

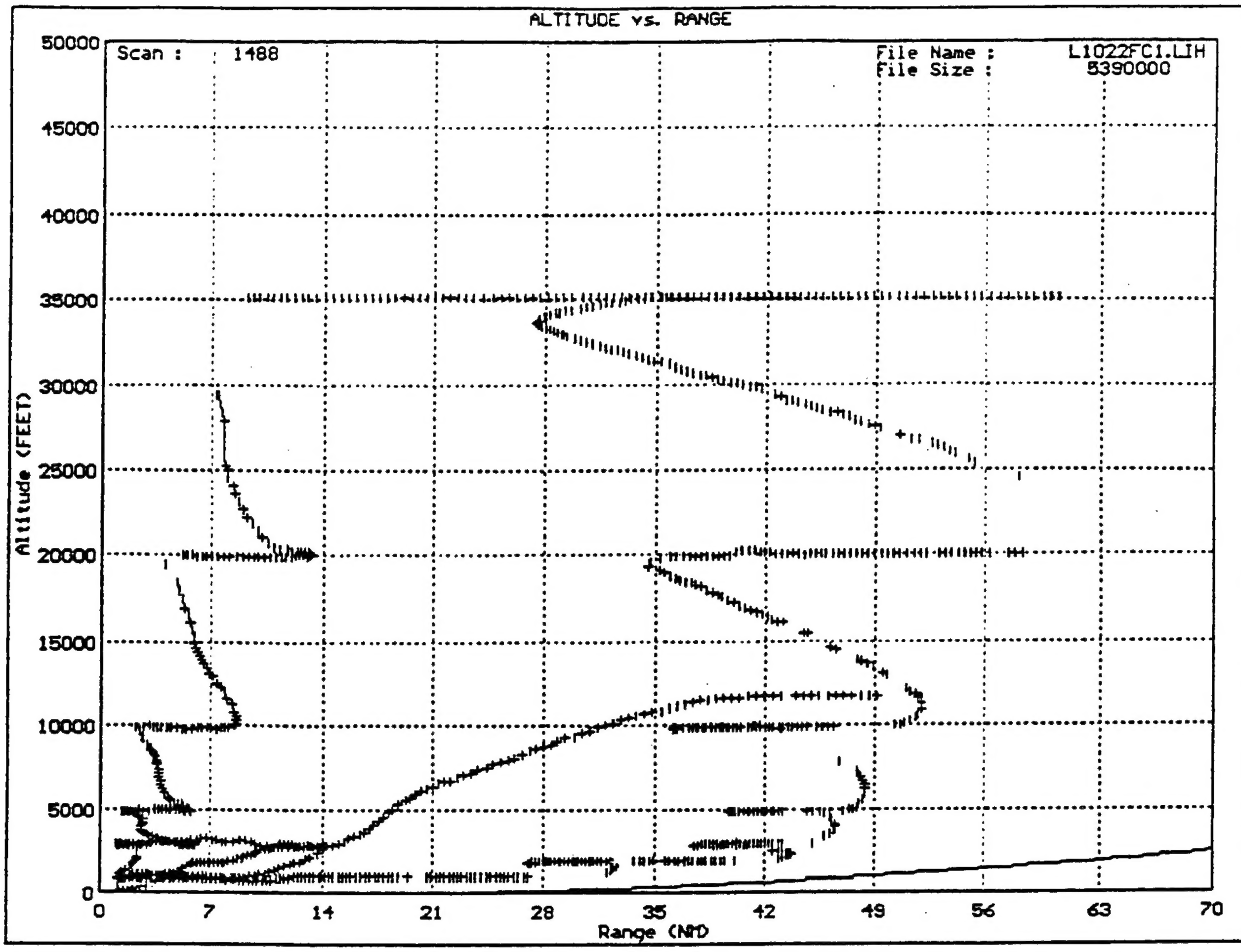


Figure 43
CD-1A

The data below is from two QARS run on two different days. They are included to demonstrate the dramatic differences in the radarÆs performance (Both beacon and search), between the flight check parameters and the normal day to day parameters. The first set of data from the two CD-1s is from the flight check. The second set is from a data set recorded with the radar in diversity, linear polarization, and the beacon at normal power. specifically note that the long range search coverage (Normal (NML) outside 32 Miles) is almost doubled from about 54% to better than 98% Blip Scan. MTI coverage is almost 10% better and beacon is 2% better.

Flight Check Configuration

LIA LIHUE CDA D O S Q A R S RADAR DATA ANALYSIS RUN DATE: 10/21/1996 DATE RECORDED: 10-18-96

SITE TOTALS

	Scans	BLP/SCN	R/R	COLL	ASPLT	RSPLT	False-BCN	Code	Reliability	DEV	** BASED ON **		MTI	CROSSOVERS
BCN	10622	97.6	61.1	90.1	0.1	0.7	RAR 0.0	M3R 98.4	MCR 99.5	0.062 NMI	TOTAL TRACKS-	106	4096 ACPS	32.0 NMI
NML	7056	55.1	50.5	91.1	0.8	0.7	REF 0.0	M3V 98.7	MCV 98.1	2.4 ACPs	MODE C SCANS-	9823	0 ACPS	0.0 NMI
MTI	3566	90.9	81.5	89.0	2.0	0.0	ZER 0.6	ARL 52.0	DMTI 0.0	EFPD 98.6	TOTAL REFLCT-	10	0 ACPS	0.0 NMI

Uncorrelated records: Beacon reports = 158, Coasted scans = 254 Antenna updates = 2223, Tracks Initiated = 142
Site has 146 code zero beacon reports, 65 were used in calculations. Avg. search/scan: NML = 26 MTI = 27

PE AND RTQC VERIFICATION

TARGET ID	SCANS CHECKED	ADAPTED RANGE	MEAN ERROR	ADAPTED AZIMUTH	MEAN ERROR	ADAPTED MODE3/A	REPORTED CODE	ADAPTED MODE1/2	REPORTED CODE	RELIABILITY PERCENT
BRTQC	2212	57.0	0.0	2088.00 ACPs	-2.88 ACPs	7777	7777	7777	0000	100.0 PCT

LIB LIHUE CDB D O S Q A R S RADAR DATA ANALYSIS RUN DATE: 10/21/1996 DATE RECORDED: 10-18-96

SITE TOTALS

	Scans	BLP/SCN	R/R	COLL	ASPLT	RSPLT	False-BCN	Code	Reliability	DEV	** BASED ON **		MTI	CROSSOVERS
BCN	10580	97.3	62.2	93.5	0.1	0.6	RAR 0.0	M3R 98.7	MCR 99.6	0.062 NMI	TOTAL TRACKS-	103	4096 ACPS	32.0 NMI
NML	7035	53.4	50.4	94.0	0.9	0.8	REF 0.0	M3V 98.8	MCV 98.7	2.3 ACPs	MODE C SCANS-	9763	0 ACPS	0.0 NMI
MTI	3545	90.9	84.9	93.0	2.0	0.0	ZER 0.5	ARL 52.2	DMTI 0.0	EFPD 98.6	TOTAL REFLCT-	4	0 ACPS	0.0 NMI

Uncorrelated records: Beacon reports = 134, Coasted scans = 290 Antenna updates = 2212, Tracks Initiated = 137
Site has 157 code zero beacon reports, 48 were used in calculations. Avg. search/scan: NML = 26 MTI = 27

PE AND RTQC VERIFICATION

TARGET ID	SCANS CHECKED	ADAPTED RANGE	MEAN ERROR	ADAPTED AZIMUTH	MEAN ERROR	ADAPTED MODE3/A	REPORTED CODE	ADAPTED MODE1/2	REPORTED CODE	RELIABILITY PERCENT
BRTQC	2212	57.0	0.0	2088.00 ACPs	-2.88 ACPs	7777	7777	7777	0000	100.0 PCT

Day to Day Operation

LIA LIHUE CDA D O S Q A R S RADAR DATA ANALYSIS RUN DATE: 10/26/1996 DATE RECORDED: 10-26-96

SITE TOTALS

	Scans	BLP/SCN	R/R	COLL	ASPLT	RSPLT	False-BCN	Code	Reliability	DEV	** BASED ON **		MTI	CROSSOVERS
BCN	3354	99.3	82.3	83.3	0.0	0.5	RAR 0.0	M3R 100.0	MCR 99.8	0.052 NMI	TOTAL TRACKS-	31	4096 ACPS	32.0 NMI
NML	2023	98.2	82.0	83.4	3.6	0.1	REF 0.0	M3V 99.9	MCV 99.3	1.9 ACPs	MODE C SCANS-	3330	0 ACPS	0.0 NMI
MTI	1331	99.5	82.7	83.0	4.3	0.5	ZER 0.0	ARL 53.2	DMTI 0.0	EFPD 99.9	TOTAL REFLCT-	0	0 ACPS	0.0 NMI

Uncorrelated records: Beacon reports = 18, Coasted scans = 24 Antenna updates = 1419, Tracks Initiated = 33
Site has 17 code zero beacon reports, 1 was used in calculations. Avg. search/scan: NML = 38 MTI = 64

PE AND RTQC VERIFICATION

TARGET ID	SCANS CHECKED	ADAPTED RANGE	MEAN ERROR	ADAPTED AZIMUTH	MEAN ERROR	ADAPTED MODE3/A	REPORTED CODE	ADAPTED MODE1/2	REPORTED CODE	RELIABILITY PERCENT
BRTQC	1424	57.0	0.0	2088.00 ACPs	-2.90 ACPs	7777	7777	7777	0000	100.0 PCT

LIB LIHUE CDB D O S Q A R S RADAR DATA ANALYSIS RUN DATE: 10/26/1996 DATE RECORDED: 10-26-96

SITE TOTALS

	Scans	BLP/SCN	R/R	COLL	ASPLT	RSPLT	False-BCN	Code	Reliability	DEV	** BASED ON **		MTI	CROSSOVERS
BCN	3354	99.9	87.2	88.3	0.0	0.7	RAR 0.0	M3R 99.9	MCR 99.9	0.051 NMI	TOTAL TRACKS-	31	4096 ACPS	32.0 NMI
NML	2025	98.3	86.7	88.2	3.6	0.0	REF 0.0	M3V 99.9	MCV 99.8	1.8 ACPs	MODE C SCANS-	3350	0 ACPS	0.0 NMI
MTI	1329	99.2	87.9	88.5	4.6	0.5	ZER 0.1	ARL 53.2	DMTI 0.0	EFPD 99.9	TOTAL REFLCT-	0	0 ACPS	0.0 NMI

Uncorrelated records: Beacon reports = 11, Coasted scans = 4 Antenna updates = 1410, Tracks Initiated = 33
Site has 10 code zero beacon reports, 2 were used in calculations. Avg. search/scan: NML = 38 MTI = 67

PE AND RTQC VERIFICATION

TARGET ID	SCANS CHECKED	ADAPTED RANGE	MEAN ERROR	ADAPTED AZIMUTH	MEAN ERROR	ADAPTED MODE3/A	REPORTED CODE	ADAPTED MODE1/2	REPORTED CODE	RELIABILITY PERCENT
BRTQC	1424	57.0	0.0	2088.00 ACPs	-2.90 ACPs	7777	7777	7777	0000	100.0 PCT